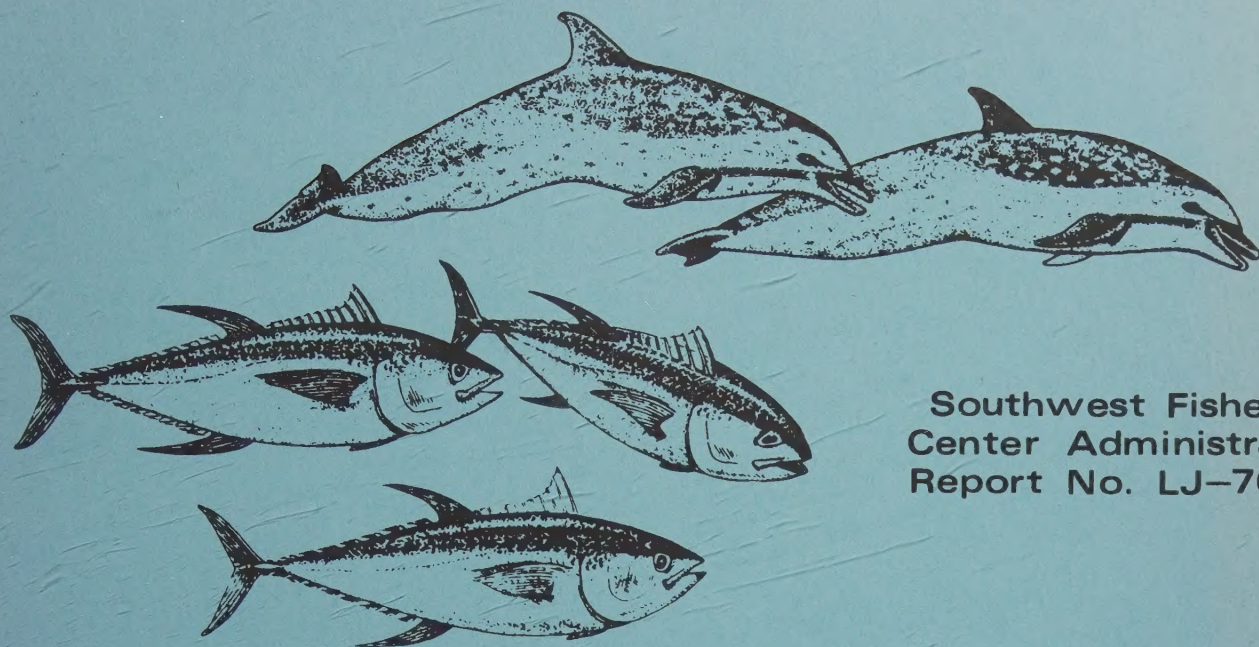




Southwest Fisheries
Center Administrative
Report No. LJ-76-17

PROGRESS OF RESEARCH ON PORPOISE MORTALITY
INCIDENTAL TO TUNA PURSE-SEINE FISHING
FOR FISCAL YEAR 1976

BY

STAFF, PORPOISE/TUNA INTERACTION PROGRAM
OCEANIC FISHERIES RESOURCES DIVISION

September 7, 1976

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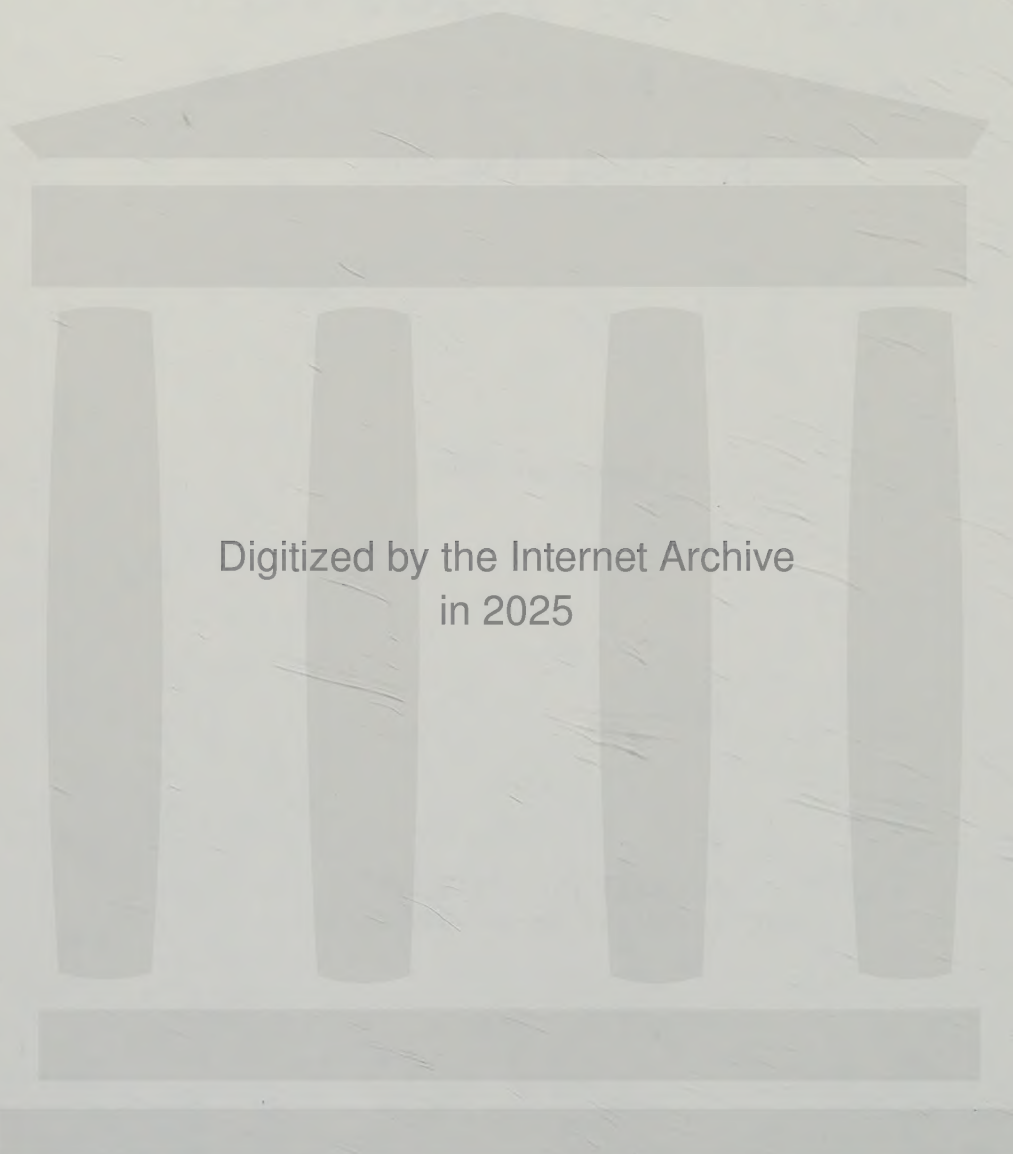
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TABLE OF CONTENTS

<u>Section</u>	<u>Title</u>	<u>Page</u>
1.0	INTRODUCTION.	1
1.1	Review of the Problem.	3
1.2	Recent Events Affecting the Research Program	7
1.3	The Research and Development Program of the Southwest Fisheries Center.	8
2.0	FLEET PERFORMANCE IN MORTALITY REDUCTION	13
2.1	Data Source.	13
2.2	Species Composition of the Kill	16
2.3	Physical Causes of Mortality	17
2.4	Quota-Oriented Calculations	17
2.5	Analysis of the U.S. Fleet Kill Rate Performance	19
2.6	Effectiveness of Regulations	28
2.7	Possible Causes of the Apparent Decline in Kill Per Set.	40
3.0	MORTALITY REDUCTION TECHNOLOGY.	42
3.1	Introduction	42
3.2	The Use of Speedboats to Prevent Collapse	44
3.3	The <i>Bold Contender</i> System.	46
3.4	Rollup Prevention Research	70
3.5	Large-Volume Purse Seine	73
3.6	The Zipper System.	75
3.7	Use of Ribbons as Current Indicators	77
3.8	Porpoise Grabbers.	77
3.9	Plans for Research in Mortality Reduction Technology	78
4.0	PORPOISE BIOLOGICAL STUDIES	79
4.1	Biological Parameters of Eastern Spinner Dolphin	82
4.2	Biological Parameters of Whitebelly Spinner Dolphin.	85
4.3	Biological Parameters of the Striped Dolphin	87
4.4	Behavioral Studies	88

TABLE OF CONTENTS (Cont'd)

<u>Section</u>	<u>Title</u>	<u>Page</u>
5.0	PORPOISE STOCK ASSESSMENT	89
	5.1 Aerial Survey.	89
	5.2 Tagging Studies.	91
	5.3 Vessel-Based Distribution Surveys.	92
6.0	SUMMARY	93
7.0	ACKNOWLEDGEMENTS	99
8.0	LITERATURE CITED	101
9.0	TABLES	105
10.0	FIGURES	123

1.0 INTRODUCTION^{1/}

Observations on the problem of incidental mortality of porpoise in the eastern Pacific purse seine fishery for yellowfin tuna have been made by NMFS scientists since 1962 but funding was not obtained to actively study the problem until 1970.

As a direct result of the Marine Mammal Protection Act (MMPA) of 1972 (16 U.S.C. 1361, 86 Stat. 1027, 1972), the research program of the Southwest Fisheries Center (SWFC) of the National Marine Fisheries Service (NMFS) was increased substantially to develop fishing methods and gear technology which would reduce the incidental mortality of porpoise in the yellowfin tuna purse-seine fishery and to determine the status of the involved porpoise stocks. Results of the SWFC research program have been documented in numerous publications and internal Administrative Reports, and have been summarized in several documents (NOAA, 1972; DOC, 1974; DOC, 1975; SWFC, 1975; and DOC, 1976).

The primary purpose of the present report is to provide information on the direction and the results of porpoise/tuna research for

^{1/} John T. Everett (Leader, Porpoise/Tuna Interaction Program) was responsible for the preparation of this report. Several members of the staff provided assistance to him--particularly important were the contributions of James M. Coe, LT. Terry Jackson, Richard L. McNeely, and Charles W. Oliver. The report was compiled in part from Administrative Reports and publications prepared by several scientists of the research program. These documents are referenced at appropriate locations in this report and are available from the Director of the Southwest Fisheries Center upon request.

Fiscal Year 1976 (July 1, 1975 to June 30, 1976) and as such it draws from and updates the report for Fiscal Year 1975 (SWFC, 1975). Because of rapidly changing events in the summer of 1976, some analyses go beyond the end of Fiscal Year 1976 so that the report will be as useful as possible in supporting decision making in the fall of 1976. The report will be utilized as background information by those making decisions relative to the issuance of a general permit allowing the tuna industry a continued incidental take of marine mammals. The present report covers:

- (1) a brief review of the porpoise/tuna problem and the SWFC porpoise/tuna research program,
- (2) an evaluation of the U.S. tuna fleet's performance in reducing porpoise mortality,
- (3) a report on developments in mortality-reduction technology,
- (4) a report on research findings on the biology of the porpoise,
- (5) an overview of stock assessment activities, and
- (6) a summary of findings.

The status of the porpoise stocks is being reported separately by a panel of experts convened to study existing and optimum population levels. The panel's report (SWFC, 1976) was not completed in time for the results to be included here.

1.1 Review of the Problem

Incidental mortality of porpoise associated with yellowfin tuna occurs in purse-seine fishing in the eastern Pacific. The mortality dates back to the late 1950's when the U.S. tuna fleet converted from fishing primarily with a live bait and hook-and-line technology to utilization of a purse seine net. This conversion was made possible through the advent of nylon netting and power blocks to handle the large nets. Knowledge of the strong porpoise and yellowfin tuna association and the development of methods to herd porpoise and then encircle them and tuna with the purse seine, increased the capability to find and capture tuna. These developments tremendously reduced the cost of catching tuna and established the U.S. tuna fleet's world prominence. The incidental mortality of porpoise has been extensively documented (NOAA, 1972; DOC, 1974; SWFC, 1975; Powers, 1976). Estimates of the catch of yellowfin tuna in association with porpoise for the years 1971-1975 and the relative importance of the U.S. and non-U.S. catch of yellowfin tuna in the eastern Pacific Ocean and the relative importance of purse seine gear are shown in Table 1. Purse seine fishing for

yellowfin tuna associated with porpoise is very important to the U.S. fishermen: between one-third and one-half of all U.S. domestic tuna landings (all species and all ocean areas) are taken in this manner.

At first the incidental porpoise mortality problem was almost entirely restricted to U.S. vessels. However, other countries fishing for tuna in the eastern tropical Pacific have developed their capabilities to purse seine yellowfin tuna in association with porpoise (Table 1). Foreign involvement in catching yellowfin tuna associated with porpoise increased markedly between 1971 and 1975. If it is assumed that the foreign kill per set of the purse seine on porpoise is equal to the average U.S. kill per set of 1972 and 1973, it is estimated that 26 percent of the 1975 kill was due to non-U.S. vessels, while in 1971 it was just 2 percent (SWFC, 1976; SWFC, 1975; Powers, 1976). Fourteen countries besides the U.S. fished for tunas in the eastern Pacific in 1975: Bermuda, Canada, Colombia, Costa Rica, Ecuador, France, Japan, Mexico, Netherlands, Panama, Peru, Senegal, Spain, and Venezuela (IATTC, 1976). Foreign involvement in catching yellowfin tuna in association with porpoise will likely continue to increase at a substantial rate. Several countries have governmental policies to expand their fisheries and have obtained relatively inexpensive capital from international sources. Furthermore, the Inter-American Tropical Tuna Commission (IATTC) associated regulations and allocation system, with relatively more effective U.S. enforcement against U.S. fishermen, and the porpoise quota have interacted to make proficient U.S. fishermen, U.S. capital,

and former U.S. vessels available to augment and improve the foreign capability. With virtually no vessels being added to the U.S. fleet and a growing foreign fleet, effective control over reduction of the total incidental porpoise mortality is decreasing.

In addition to the expansion of foreign fishing associated with porpoise, which would place a greater proportion of the total porpoise mortality outside direct U.S. controls, there are several factors which also act to impede reduction of the total incidental porpoise mortality (SWFC, 1975):

- (1) IATTC-associated tuna conservation regulations, which tend to increase fishing in areas where porpoise-associated tuna predominate in the latter half of the year,
- (2) Extension of seaward jurisdiction by Central and South America countries, which reduces possibilities for catching nearshore tuna not associated with porpoise and tends to decrease availability of bait needed for fishing with hook and line,
- (3) Fishing for yellowfin associated with porpoise in areas outside the Commission Yellowfin Regulatory Area (CYRA-- Figure 1) adds to the total tuna supply available. These fish are generally not available to other fisheries and to a large extent are an additional resource.

Conversely, there are three factors that promote the reduction of incidental porpoise mortality. One factor is the clear U.S. legal requirement that porpoise mortality be reduced. A second arises from the humanitarian aspects of porpoise rescue. The third is a response to the economics of the fishing operation--it is time-consuming for extensive porpoise mortality to occur in a set of the purse seine, the safety of the crew is jeopardized, and reductions in porpoise populations will eventually lead to decreased fishing efficiency (SWFC, 1975).

Prior to governmental intervention, U.S. fishermen attempted to solve the problem of incidental mortality. The U.S. fishermen's actions have included development of the backdown procedure for releasing encircled porpoise, development of the porpoise safety panel (Medina panel) to retard entanglement, and manual removal of live porpoise from within the net. Government analyses have supported the efficacy of these developments. Additional measures, procedures, and equipment were instituted in a series of regulations for the 1973-1976 fishing seasons. Discussions of these developments are contained in NOAA (1972), in DOC (1974), in SWFC (1975), and in subsequent sections of this report.

Research efforts by foreign governments on the reduction of porpoise mortality have been limited. In 1974, Canada placed field technicians aboard several of its vessels to record data on incidental porpoise mortality. Efforts by international organizations on the

porpoise mortality problem, however, are increasing. IATTC is presently preparing a background paper on the problem for its fall 1976 meeting. The member countries of IATTC voted in favor of a special allocation of 1,000 short tons of yellowfin tuna from the CYRA quota for use by the U.S. research program during 1975 and again in 1976. The Food and Agricultural Organization of the United Nations (FAO) has established a committee on small cetaceans which has recommended an international research program. The Scientific Committee of the International Whaling Commission (IWC) has established a standing committee on small cetaceans to collect and analyze data on the status of porpoise stocks. In its June 1976 meeting, the IWC passed a resolution requiring member nations to report incidental kills of cetaceans in tuna purse-seine and other fishing operations.

1.2 Recent Events Affecting the Research Program

On December 5, 1975, NMFS announced that a quota on the incidental kill of porpoise by the U.S. fleet would be imposed for 1976 if the U.S. portion of the 1976 kill were not lowered to 70% or less of the 1975 kill. The periods for comparison were chosen as January 1 through April 14 of each year. Analysis (Fox, Powers, and Lenarz, 1976) showed that the U.S. kill had dropped well below the 70-percent decision point (actually to 33 percent of the 1975 level) and therefore no quota was imposed. However, in May 1976, Judge Charles R. Richey of the U.S. Circuit Court of the District of Columbia ruled that NMFS had not met certain legal requirements of the MMPA in issuing a permit to the tuna

industry and voided the tuna industry's permit, putting a stop to purse-seine fishing for tuna associated with porpoise effective on May 31, 1976 (U.S. District Court for the District of Columbia, 1976). In appealing that decision NMFS obligated itself to instituting a quota of 78,000 porpoise, to increase its observer program from the original plan of 45 trips to 55 trips, and to determine the existing and optimum population sizes for each of the species of porpoise involved in the fishery. Judge Richey's decision was upheld on August 6, 1976 but the ruling allowed purse-seine fishing on porpoise to continue through 1976. The stay was granted to avoid a disastrous impact on the industry, to allow time for the Government to comply with the requirements of the MMPA and to enable the continuance of ongoing gear studies throughout the entire fishing season. (U.S. Court of Appeals, 1976.)

1.3 The Research and Development Program of the Southwest Fisheries Center (SWFC)

1.3.1 Program approach

The SWFC Porpoise/Tuna Interaction Program has three basic objectives:

- (1) Develop methods and technology to reduce porpoise mortality incidental to yellowfin tuna purse seine fishing;
- (2) Determine the status of the porpoise stocks;

- (3) Monitor the incidental mortality by the U.S. fleet throughout the year.

The program consists of four components: a) mortality reduction technology, b) general biology and behavior, c) stock assessment, and d) quantitative analysis and data management. These components will be considered in detail in subsequent sections of this report.

The SWFC attempts to bring together all parties interested in solving all or portions of this complex problem so that resources can be pooled and greater results achieved. For example, the SWFC is working with the Marine Mammal Commission (MMC), Naval Undersea Center (NUC) and San Diego State University (both under National Science foundation sponsorship), the University of California at Santa Cruz (under MMC sponsorship) and the Porpoise Rescue Foundation (PRF) in developing a baseline knowledge of porpoise behavior during tuna fishing operations.

The PRF was recently chartered as an organization through which tuna processors, boat owners, and labor unions could channel resources towards solving the porpoise/tuna problem. This organization had a first-year budget of \$250,000--most of which was used to support a large-scale test of two experimental net designs in cooperation with NMFS.

Another example of a broad cooperative research program is that being undertaken to develop a satellite-linked radio tracking

device for use on porpoise. This project involves the MMC, NUC, National Aeronautics and Space Administration (Goddard), Southwest Fisheries Center, PRF, National Data Buoy Program, and the Southeast Fisheries Center (Fisheries Engineering Laboratory, 1976). Each group is involved for specific reasons--not necessarily related to the porpoise/tuna problem--and brings special talents and resources to the cooperative project.

SWFC staff have participated in an advisory role during the formation of the Skippers' Panel of the PRF, have provided biological training to the porpoise observers of the NMFS Southwest Regional Office, and have participated in Certificate Holder training workshops.

Present program priorities were developed in consultation with the MMC, PRF, NUC, environmental groups, the Council on Environmental Quality and other interested parties in a series of meetings in late 1975 and early 1976.

1.3.2 Administration

The Porpoise/Tuna Interaction Program is one of two programs in the Oceanic Fisheries Resources Division of the SWFC. At the end of Fiscal Year 1976 (July 1, 1975 to June 30, 1976), 18 permanent positions had been allocated for the work of the program. Of these 18 positions, two were filled by NOAA Corps officers, two vacant positions were about

to be filled, and one was part-time. Eight positions were filled by senior scientific employees, two of whom had duties in other programs of the SWFC. The end of the fiscal year saw a reduction in the temporary staff from 30 to 18 as the peak of the government/industry cooperative gear experiment passed. Of the 18 temporary employees, there were eight gear technicians, eight data processing technicians, one biological technician, and one clerk/typist. During the last year the program has been increased by one permanent senior scientist position and six junior scientists and technicians. Most of the growth occurred near the end of the year and has been in the area of quantitative analysis (i.e., statisticians and programmers) to support the monitoring of porpoise mortality within the year and to process the 150% increase in data for 1976.

To the regular funding of the program of about \$550,000, one-time funding of \$450,000 was added as the NMFS portion of the government/industry cooperative research program. NOAA research vessels were used for 118 days to investigate porpoise stock boundaries and distributions; the value of this ship time is conservatively estimated to be \$310,000. In addition, the IATTC allocation of 1000 tons of yellow-fin tuna obtained 143 days of gear research at sea aboard commercial tuna seiners worth approximately \$715,000 ($\$5,000 \times 143$ days) if NMFS had had to buy the vessel days.

Allocation of the FY 1976 funds were as follows (some of the funds were distributed to the SWFC late in the fiscal year and will actually be spent in the summer of 1976):

NMFS FY 1976 PORPOISE/TUNA RESEARCH FUNDING

Regular Funding (Including 1976 Increase)

Stock Assessment	\$180,000
Mortality Reduction	120,000
Biological Studies	160,000
Quantitative Analysis and Data Management	<u>90,000</u>
Subtotal	\$550,000

NMFS/Industry Cooperative Program

Mass Gear Test	\$290,000	
Tooth Age Reading	50,000	
Rollup Prevention	35,000	
Behavioral Work	50,000	
School Size Studies	<u>25,000</u>	
Subtotal	\$450,000	
Total		\$1,000,000

This total level of funding compares with the total (regular plus one-time) funds for Fiscal Year 1975 of \$590,000 and expected Fiscal Year 1977 funding of \$1,150,000 for porpoise/tuna research. It should also be pointed out that funding of the NMFS Porpoise Observer Program is now the responsibility of the Southwest Regional Office and is not included here. This transfer occurred in the summer of 1975.

2.0 FLEET PERFORMANCE IN MORTALITY REDUCTION

With the institution of a quota on the number of porpoise that could be killed in 1976 during tuna purse-seining operations by the U.S. fleet it has become very important to monitor the cumulative mortality during the year and to continue analyses of the U.S. fleet kill rate performance (i.e., kill per porpoise set). This section discusses the methods and results of these analyses and the effectiveness of certain NMFS regulations in reducing porpoise mortalities. The conclusions of all sections of this report are summarized in Section 6.0. An analysis of pre-1976 mortality is contained in the Porpoise Stock Assessment Workshop Report (SWFC, 1976).

2.1 Data Source

The Porpoise/Tuna Interaction Program relies heavily on data recorded by NMFS observers carried aboard U.S. tuna seiners. In 1976 every vessel fishing for tuna associated with porpoise must carry a person holding a certificate of inclusion under the general permit granted to the American Tunaboat Association. NMFS regulations were altered for 1976 such that vessels with certificate holders are now required to carry NMFS observers (when requested) as a condition for being allowed to fish on porpoise. The Observer Program is now operated by the NMFS Southwest Regional Office at Terminal Island, California. The transfer of funding and responsibility from the SWFC took place

during the summer of 1975. The observers, who are biological technicians, continue to collect specimens for use in the SWFC Biological Studies Task and they continue to record the same types of information collected in 1975 plus regulation compliance data for the Regional Office. The observers are placed aboard vessels from a list developed in a random drawing. The Regional Office altered past procedures such that the list has become a perpetual list and further drawings will be held only to add (in random order) new vessels or vessels joining those carrying certificate holders.

In 1975, after obtaining 22 trips inside the CYRA,^{2/} attempts were made in the last half of the year to obtain up to 12 observer trips outside the CYRA (SWFC, 1975). None was obtained and this prompted, at least in part, the change in the 1976 regulations making observer trips a mandatory requirement for obtaining a certificate of inclusion under the general permit issued to the American Tunaboat Association.

The variance of the kill estimate did not change in 1975 from previous years, so when it was decided to sample the fleet during 1976 to estimate the total kill (as opposed to observers on every U.S. vessel), 36 trips were again recommended as in 1975. However, the quota calculations for early 1976 required an increase in precision for this time period, so nine additional trips were recommended (for a total of 45). As a result of the legal proceedings in May and June in which NMFS

^{2/}Inter-American Tropical Tuna Commission Yellowfin Tuna Regulatory Area (Figure 1).

raised the total number of observers to 55, data from at least 15 trips which will fish, at least in part, outside the CYRA are expected.

The placement of observers aboard certificated vessels in 1976 will be distributed as follows (the 10 additional observers were added to Round 3):

<u>Vessel Class</u>	<u>Round 1</u>	<u>Round 2</u>	<u>Round 3</u>	<u>Total</u>
Class I (<u><400 tons</u>) [*]	3	1	2	6
Class II (<u>>400 tons, <1961</u>) ^{**}	3	3	3	9
Class III (<u>>400 tons, >1960</u>) ^{**}	<u>19</u>	<u>6</u>	<u>15</u>	<u>40</u>
Totals	25	10	20	55

* Tons are carrying capacity tonnages

** Year is date of construction

A round 1 trip is generally the first trip of the year for the selected vessel. These trips are generally associated with considerable fishing on porpoise. A round 2 trip generally is the second trip of the year and usually begins within 30 days of closure of the CYRA to unregulated yellowfin tuna fishing; they are less heavily dependent on fishing on porpoise. A round 3 trip usually occurs during the last half of the year. These are regulated trips which fish by and large outside the CYRA and are heavily dependent on porpoise fishing. Round 3 trips

may fish inside the CYRA under IATTC regulations on certain allowable percentages of yellowfin in their catch based on vessel size (e.g., small vessels such as some in NMFS Class I can catch as much as 60% yellowfin whereas all Class II and III vessels are limited to 15% yellowfin). As noted previously, the round 3 trips of this year will provide our first solid data on fishing on porpoise outside the CYRA.

2.2 Species Composition of the Kill

The species composition of the kill during the first half of the year changed little between 1976 and 1975. However, the percentage kill of spinner dolphins has shifted sharply toward the whitebelly form in the first half of 1976. This shift is due to a preponderance of 1976 early-season fishing in southern regions which is likely to be outside of the range of the eastern form. Table 2 presents the tabulation of killed and seriously injured spotted, spinner and common dolphin for the first half of 1976. The serious injury rate decreased from 5 percent of the observed kill in 1975 to 3.5 percent in 1976. The percentage of the kill for 1975 and 1976 is presented below.

<u>Species</u>	<u>Percentage of kill</u>	
	<u>1975</u>	<u>1976*</u>
Spotted dolphin	58	61
Spinner dolphin	35	33
Eastern	18	3
Whitebelly	15	28
Unidentified	2	2
Common dolphin	6	3
Other	1	3
Total	100	100

*First 6 months

2.3 Physical Causes of Mortality

Table 3 shows the physical causes of mortality by species in the first half of 1976. Entanglement is a relatively more important cause of mortality in 1976 than it was in 1975, while "sacking up" (the final operation prior to loading the tuna on the vessel) as a cause, has dropped considerably. Entrapment and "other" causes have changed very little. Table 4 compares the kill per set figures of the various causes of mortality between all of 1975 and the first 30 observed trips of 1976. For 1976, there is little change in entanglement, a drop in entrapment and a drop in "sacked up" as causes of mortality. There has been a 30-percent drop in the overall kill per set of spinner porpoise and almost no change in the kill per set of spotted porpoise. There has been a 29 percent drop in the kill per set of other species. The total kill per set figures in Table 4 are higher than those found elsewhere in this report because only sets with porpoise killed can be included in the analysis.

2.4 Quota-Oriented Calculations

As a result of the announcement (*Federal Register*, 1975) that no quota would be set in 1976 if a 30% reduction in the U.S. kill during the early part of 1976 was obtained in comparison to the early part of 1975, a methodology for the comparison was developed in consultation with the Marine Mammal Commission and after several public meetings (*Federal Register*, 1976a). The resultant analysis (Fox, Powers, and

Lenarz, 1976) indicated that the kill had dropped about 67 percent during the January to April 15 period of 1976 (74,352 versus 24,199). About two-thirds of this reduction was attributable to an increased catch of tuna not associated with porpoise and the balance was due to an improvement in releasing porpoise during porpoise sets.

Although the fleet had met the conditions required by NMFS for continued fishing on porpoise, Judge Richey ruled that NMFS had not fully complied with the MMPA and that the general permit allowing fishing on porpoise was invalid. In the ensuing appeal, NMFS expanded the Observer Program by 10 trips (to 55) and instituted a quota for incidental kill of 78,000 porpoise in 1976.

A methodology was developed to monitor the kill and project the closure date on a monthly basis. The first step involved computing the kill through June 30 by multiplying kill per day (from observed trips) times all fleet days for incomplete trips and kill per trip (from observed trips) times all complete trips. Four strata were used for vessels: Classes I, II, and III, and Experimental (i.e., the 20 gear test vessels--see Section 3.3.4). In addition, trips were grouped into three time periods in order to treat the effects of early-season and late-season fishing which are more dependent on porpoise than the April-June period. In the experimental gear strata, only kill per day was used for projection to vessels with experimental gear not carrying field technicians.

In the second step--the projection of the kill for the rest of the year--kill per ton obtained from observed trips was multiplied by the mean historic monthly catch of yellowfin on porpoise from IATTC records (1971-1975) to yield the monthly kill of porpoise. Details of the projection methodology were published on July 27, 1976 (*Federal Register*, 1976b).

A calculation was made in July 1976 (Everett and Lo, 1976) showing that the central estimate of the 1976 kill through June 30 was 42,346; the approximate 95 percent confidence interval was 30,612 to 54,080. A projection was made of the kill for the rest of the year. This projection indicated that if the kill rate (kill per ton of yellowfin on porpoise) was constant throughout the year, about 71,000 porpoise would be killed during the year and the quota would not be reached. Analysis indicated, however, that if the kill rate on two recently completed trips outside the CYRA was representative of that kind of trip, then the quota could be reached during the last 3 months of the year. A subsequent calculation in August 1976 has not changed the above estimate of 1976 kill or the possible significance of the outside-the-CYRA data.

2.5 Analysis of the U.S. Fleet Kill Rate Performance

Table 5 presents an overview of many statistics of interest concerning the porpoise/tuna fishery for the years 1971 to 1976. Caution

must be used in interpreting these statistics. For example kill per set and kill per ton are not adjusted for fishing conditions, i.e., numbers and species of porpoise and quantities of tuna caught. However, these statistics are useful in portraying general trends. The 1976 statistics show increases in the average size of porpoise schools set on, the percentage of the school captured and the number captured. The 1976 figures dealing with performance in reducing mortality per porpoise set show improvement when compared to the long-term averages. Compared to 1975, 1976 kill per set is 25 percent lower, kill per ton is 31 percent lower, kill per porpoise captured is 48 percent lower, the percent of sets with zero kill is 31 percent higher, and the percent of captured porpoise that are released has risen to 98.7 percent.

Table 6 and Figure 2 present the frequency distribution of porpoise kill per set for all porpoise sets from 1971 to 1976. The increase with time in frequency of sets having zero porpoise kill can be seen. The percent of sets having a kill greater than 50, however, has not changed significantly for the last 4 years (9% in 1973, 5% in 1974, 8% in 1975, and 6% in 1976).

The primary observation in an analysis of kill rate is the kill per set. Factors such as tuna catch, porpoise school type, and number of porpoise captured affect kill per set. Kill rates not expressed as kill per set form a simple attempt to correct for just one of the variables which contribute to the kill per set (i.e., kill per ton

and tons of yellowfin per set, and kill per porpoise captured and number of porpoise caught per set). The kill per set for the first 30 observer cruises of 1976 is plotted against these variables in Figure 3. In comparing the plot of kill per set versus quantities of tuna and porpoise captured in 1975 (SWFC, 1975) and 1976 (Figure 3) it was found that the kill per set for spotted porpoise has changed little between the years when plotted against these variables. For example, when 50 tons of yellowfin are captured the average kill per set in both years is 16; for 10 tons it is three per set in both years. When 2000 porpoise are captured the kill per set is 15 in 1976 and 12 in 1975; for 400 porpoise the kill per set is three in 1976 and five in 1975.

In comparing the plots of the mixed schools of spotted and spinner porpoise against quantities of tuna and porpoise caught, a large reduction in kill per set was noted between the 1975 and 1976 data. For 50 tons of yellowfin, the kill per set is 66 in 1975 and 48 in 1976. For 10 tons the figures are 18 and 14, respectively. When 2000 porpoise are captured the kill per set is 48 in 1975 and 27 in 1976; for 400 porpoise it is 10 and seven, respectively.

Each variable described above is related to the kill per set and each variable has differed among years (Table 5, items 2-9). To make a fair comparison between the years, one must examine the kill per set for each year on the same school type (e.g., spotted porpoise only, or mixed spotted and spinner), similar number of porpoise captured, and similar amount of yellowfin tuna captured.

In the following analyses, only data from 1973, 1974, 1975 and 1976 were used because of a paucity of data for 1971 and 1972. Only those data from the first half of each year were used in order to improve comparability with those of 1976. Furthermore, as shown in Table 5, nearly all sets have been made on either pure schools of spotted dolphin or mixed schools, and the majority of the data were obtained from Class III vessels; thus the small amount of data from other vessel classes and from other porpoise school types have not been used in the present analysis.

The set data were examined by school type, number of porpoise captured, and tons of yellowfin caught. Estimates of porpoise captured and yellowfin caught are made by the fishermen. While estimates of catch of yellowfin are considered to be reasonably accurate, it is difficult to estimate precisely the numbers of porpoise, particularly when large numbers are involved. However, by classifying the sets into only four groups (those sets in which the number of porpoise captured is between 0-500 or greater than 500 and yellowfin caught is between 0-20 tons, or greater than 20 tons), the statistics are reasonably reliable. Having only four groups avoids groups with only a few sets. In addition, there is a regular relationship of increasing kill per set with increasing number of porpoise and tons of yellowfin captured (Fig. 3), hence finer groupings than this would not alter the conclusions reached below.

An analysis was performed to determine whether there was a need to maintain these groupings. The approach in the analysis was as follows:

Tests for differences between set types in 1974 were conducted using the non-parametric Kruskal-Wallis one-criterion variance analysis test. The following conclusions were drawn (based upon a significance level of $\alpha = 0.05$):

- (1) there were differences in kill per set between pure and mixed schools,
- (2) there were differences in kill per set between the four set types for both pure and mixed schools,
- (3) there was a difference in kill per set for mixed schools with greater than 500 porpoise encircled as opposed to 500 porpoise or less. There was no significant difference in this test for pure schools of spotted dolphins,
- (4) There were differences in kill per set for both pure and mixed schools in which more than 500 porpoise were encircled and more than 20 tons of yellowfin were caught as opposed to 20 tons of yellowfin or less being caught,

- (5) There were differences in kill per set for both pure and mixed schools in which more than 20 tons of yellow-fin were caught as opposed to 20 tons or less.

In summation, there were significant differences in kill per set for each set type except between pure spotted dolphin schools greater than 500 captured and 0-500 captured. Therefore, the manner in which the sets are distributed among the set types will substantially affect the total kill per set. This therefore justifies the use of standardized fishing conditions for comparisons of kill per set during different time periods as was done in last year's report (SWFC, 1975) and the following analysis in this report. The standard fishing conditions remain those of 1975 as in last year's report (SWFC, 1975).

2.5.1 Comparison of kill per set in sets on pure schools of spotted dolphins

The statistics for sets on pure spotted dolphin schools (Table 7) indicate that the kill per set on spotted dolphin declined 23% between 1973 (8.03) and 1974 (6.17); 26% between 1974 (6.17) and 1975 (4.56); and 6% between 1975 (4.56) and 1976 (4.30). Examination of the kill per set for each year reveals that the 1976 rate was the lowest among the years in sets capturing 0-500 porpoise and the second lowest in sets capturing more than 500 porpoise (Fig. 4).

Since the kill of porpoise is related to the size of the catch of yellowfin and porpoise in the net, and since the distribution of sets in the four groups differed somewhat among the years (Table 7), the kill per set standardized to 1975 conditions of porpoise and tuna catch on pure schools of spotted dolphins was calculated for 1973, 1974 and 1976 (Fig. 5).^{3/}

The statistics for the 4 years are:

<u>Year</u>	<u>Observed</u>	<u>Standardized</u>	<u>Percent reduction in standardized kill/set from previous year</u>
1973	8.03	7.81	-
1974	6.17	6.95	11
1975	4.56	4.56	34
1976	4.30	3.86	15

The decline in kill per set under standardized conditions for pure schools of spotted dolphins between 1975 and 1976 is 15 percent and between 1973 and 1976 is 51 percent.

2.5.2 Comparison of kill per set in sets on mixed schools consisting of spotted and spinner dolphins

Data from sets made on mixed schools consisting of spotted and spinner dolphins were also compiled by catch of porpoise and yellowfin

^{3/}The calculation for 1976, for example, is $(155 \times 1.96) + (42 \times 4.63) + (11 \times 2.80) + (21 \times 16.85)$ divided by $(155 + 42 + 11 + 21)$, which is equal to 3.86.

(Table 8). The overall kill per set for all sets decreased markedly between 1973 (38.30) and 1974 (20.94), increased somewhat between 1974 (20.94) and 1975 (23.97) and declined to the lowest level encountered, 19.19, in 1976. Upon examination of the individual groups of kill per set as in the pure spotted school analysis, it is apparent that 1976 was the lowest in all four of the categories of catches of porpoise and yellowfin (Fig. 4).

As in the case of sets made on pure spotted dolphins, kill per set increased when either porpoise captured or yellowfin caught increased and since the distribution of these sets among groups differed between years (Table 8), kill per set on mixed schools for 1973, 1974, and 1976 was standardized to the fishing conditions of 1975 (Fig. 5).

The statistics for the 4 years are:

<u>Year</u>	<u>Observed</u>	<u>Standardized</u>	<u>Percent reduction in standardized kill/set from previous year</u>
1973	38.30	43.03	-
1974	20.94	29.90	31
1975	23.97	23.97	20
1976	19.19	18.89	21

The kill per set in 1976 declined below that for the previous year, 1975, and continued the steady decline observed over the past 4 years. The decline in kill per set under standardized conditions for mixed schools of spotted and spinner dolphins between 1973 and 1976 is 56 percent.

2.5.3 Comparison of average kill per set for all sets standardized for school type, school size, and catch of yellowfin tuna

The average kill per set on pure spotted dolphin schools and mixed schools combined show a decline between 1973 and 1974, an increase between 1974 and 1975, and a decline to just above the 1974 level in 1976 (Table 9). This is in agreement with the summary statistics (Table 5). Table 9 also shows that the fraction of sets on mixed schools decreased from 53% in 1973 to 46% in 1974, but increased to 60% in 1975 and 1976. Since it was shown that the kill rates for mixed sets are consistently higher than that for pure spotted dolphin schools (Fig. 5), a change in school-type composition has an appreciable effect on the average kill per set from all sets (Tables 5 and 9). In order to compare the average kill per set for all porpoise sets by the U.S. fleet in 1973, 1974, 1975, and 1976 under comparable conditions, a standardized (to 1975 conditions) kill per set was calculated which accounts for variation in the distribution of yellowfin and number and species composition of porpoise captured (Fig. 5).

The statistics for the 4 years are:

<u>Year</u>	<u>Observed</u>	<u>Standardized</u>	<u>Percent reduction in standardized kill/set from previous year</u>
1973	24.05	28.78	-
1974	12.93	20.61	28
1975	16.12	16.12	22
1976	13.17	12.81	21

The decline in kill per set from 1975 to 1976 is 21 percent. The overall decline in kill per set from 1973 to 1976 is 55 percent when fishing conditions are standardized to those found in 1975.

The fact that conditions can be very different among years is shown by the 60% difference between standardized (20.61) and observed (12.93) values for 1974.

2.6 Effectiveness of Regulations

On December 5, 1975 NMFS published the regulations for the 1976 fishing season governing the fishing for yellowfin tuna associated with porpoise (*Federal Register*, 1975). In this section, a report is given on the effectiveness of certain of these regulations: 1) use of rescuers, 2) use of speedboats, 3) porpoise safety panel, and 4) backdown.

2.6.1 Rescuer Effectiveness

The NMFS regulations for 1976 state that commencing with backdown and continuing through the sacking up operation, at least two men ("rescuers") are to be engaged in hand removal of porpoise from the net. All live porpoise must be removed from the net prior to initiating brailing operations (*Federal Register*, 1975). The effectiveness of rescuers in releasing porpoise was analyzed and is reported below.

Table 10 presents the rescue statistics for those sets in which live porpoise were left in the net after backdown.

The incidence of use of rescuers during sets in which live porpoise were left in the net after backdown increased from 1975 to 1976 and there was a concomitant increase in the percent of those porpoise that were rescued:

	<u>Ave. no. rescuers per set</u>	<u>Percent sets using two or more rescuers</u>	<u>Percent of live porpoise in net after backdown which are rescued prior to sack-up</u>
1975	1.91	67	59
1976	2.40	90	67

The 1975 data are for the whole year, whereas the 1976 data are for the first 30 observer trips. Increased use of rescuers appears to have increased the percent of porpoise rescued. There was also a decrease in

the kill per set caused by sacking up in 1976 (Table 4) which may be primarily attributable to rescuer deployment. The number of rescuers per number of live porpoise left in after backdown during 1976 was analyzed relative to percent of the live porpoise rescued prior to sack-up and the mortality associated with sack-up.

<u>No. rescuers per no. live porpoise in net</u>	<u>Ave. no. rescuers per no. in net</u>	<u>Percent of live porpoise rescued prior to end of sack-up</u>	<u>Kill per set associated with sack-up</u>
0 to 0.050	0.02	53	5.07
0.051 to 0.100	0.08	73	1.30
0.101 to 0.150	0.13	79	0.54
0.151 to 0.200	0.19	82	0.48
0.201 to 0.250	0.25	76	0.00
>0.250	0.49	86	0.10

Both percent rescued and kill per set are not distributed uniformly over the intervals (Kolmogorov-Smirnov statistic, $\alpha = 0.05$) indicating statistically that increasing the number of rescuers per number of live porpoise will increase the percent of those porpoise being rescued and decrease the kill per set caused by sack-up.

Comparing the distribution of sets between 1975 and 1976 over the same intervals showed that there was a statistical increase in the number of rescuers per live porpoise in the net in 1976 as opposed to 1975:

<u>No. rescuers per no. live porpoise in net after backdown</u>	<u>No. sets with live porpoise after backdown</u>		<u>Kill per set associated with sack-up</u>	
	<u>1975</u>	<u>1976</u>	<u>1975</u>	<u>1976</u>
0 to 0.050	108	23	10.21	5.07
0.051 to 0.100	125	33	4.74	1.30
0.101 to 0.150	82	33	1.75	0.54
0.151 to 0.200	94	38	1.17	0.48
0.201 to 0.250	28	11	1.11	0.00
>0.250	240	143	0.24	0.10

Also, it can be shown from the above that for a given number of rescuers per live porpoise in the net, the kill per set associated with sack-up was less in 1976 (Wilcoxin matched-pairs signed-ranks test) indicating not only that more rescuers were used, but that they are more efficient in releasing porpoise.

Therefore, the conclusions to be drawn relative to rescuer effectiveness are:

- (1) the number of rescuers used per live porpoise in the net increased in 1976 as compared to 1975 and the kill per set associated with sack-up decreased.
- (2) increasing the number of rescuers for a given number of porpoise left in the net will increase the probability of a porpoise being released and decrease the mortality associated with sack-up.

- (3) rescuers were significantly more efficient in rescuing porpoise in 1976 than in 1975.

Hence, the decrease in kill per set caused by sack-up and the increase in percent rescued after backdown and prior to the end of sack-up may be attributable both to the increased use of rescuers and more efficient rescuers.

The frequency distribution of rescuers for 1975 and 1976 is shown in Figure 6.

2.6.2 The use of speedboats in reducing porpoise mortality

The primary use of speedboats in tuna purse seining operations is to herd porpoise into a tight school so that the main vessel can set the purse seine around the school, thus entrapping the porpoise and any tuna that are associated with them. The porpoise remain in the pursed area until about two thirds of the net is brought aboard and the vessel is able to backdown and pull the net from under the porpoise. Backdown and other rescue techniques are effective in safely releasing about 99 percent of all the porpoise captured (Table 5). However, under certain conditions of current, weather or vessel malfunction, loose pockets of webbing form or the corkline comes together and restricts the area available for porpoise to reach the surface to breathe. In prior years, examinations of porpoise observer set logs showed net collapses before

backdown to be a significant source of porpoise mortality. It was demonstrated that speedboats could be useful to prevent net collapse and, in some situations, straighten out loose webbing.

The 1976 regulations require the use of speedboats in reducing net collapse and folds of loose webbing. On every set involving marine mammals, a minimum of two manned speedboats (except that Class I vessels need only one), is to be in the water until backdown commences. Speedboats are to be prepared to hook onto bunchline towing points established along the perimeter of the net in order to tow the net to prevent net collapse and formation of pockets of loose webbing, such as stern bends, which might entrap marine mammals. Other speedboats that are in operating condition are to be prepared for immediate use to tow if needed.

Actual towing on the net is to be performed when, in the opinion of the certificate holder, towing is necessary to prevent net collapse or the formation of pockets of loose webbing. If towing the net has been necessary, the speedboats may unhook their towlines when towing is no longer needed, or their respective bunchlines begin to go up toward the power block or backdown commences (*Federal Register*, 1975).

An analysis was performed on the use of speedboats in reducing porpoise mortality through towing on the net in order to reduce the incidence of collapse and the formation of loose pockets of webbing

(Everett, Powers, McNeely, Coe and Butler, 1976). A listing of key findings is presented below.

- (1) Conditions warranting the use of speedboats to tow on the net occurred in 17 percent of 470 observed porpoise sets (i.e., in 73 sets towing occurred and in eight sets collapse occurred when there was no towing). Keeping speedboats in the water is highly correlated with adverse fishing conditions (large quantities of porpoise and tuna and mixed porpoise schools) and equipment malfunctions; however, the actual use of speedboats is not highly correlated with these factors.
- (2) The earlier a problem is identified and sufficient speedboats hooked up, the more likely that collapse will be averted. In some sets with general collapse and late use, speedboats were able to hold open areas of the net where most of the porpoise were located.
- (3) Early use of two speedboats towing from their sterns and on the bunchline appears to eliminate or greatly reduce the occurrence of net collapses (12 of 12 sets in the sample plus the experience on NMFS charters (reported in the Mortality Reduction section of this report)). The

NMFS observer set logs indicate, however, that some severe current conditions may require three speedboats. In the 470 sets, three speedboats may have been needed on not more than five sets.

- (4) Towing from the bow of the speedboat and/or on the corkline is appropriate under certain conditions. For example, towing from the bow is appropriate when shoaled webbing might foul the propeller, when there would be a high-following sea if towing from the stern, or when only a small amount of power is needed. The corkline can or should be pulled on when it is tight, when bunchlines are not available or when a net canopy forms under a tight corkline.
- (5) In all eight sets with collapse where no speedboats towed, collapse probably could have been averted by towing with one or two speedboats. In all cases with collapse, except two, towing began late in the development of a problem. In the two exceptions, an additional speedboat was required and better deployment was necessary.
- (6) The use of speedboats to tow on the net is up by a factor of six in 1976 (15.5%) when compared to 1975 (2.6%). The 1976 incidence of collapse (4.9%) and the percent of kill

due to collapse (10.6%) is about half that of 1975 (10.1% and 19.6%, respectively). If the 1975 rate of collapse (10.1%) and kill per set due to collapse in sets with collapse (32.1) had existed in 1976 (4.9% and 28.7, respectively), the kill in Class II and III vessels would have increased by two animals per set. We believe that most of the drop in the 1976 collapse figures is due to towing with speedboats.

- (7) Having two speedboats in the water does not lengthen the time of set nor does it lead to increased porpoise mortalities. It may actually decrease mortalities if the speedboats are used to chase porpoise out of problem areas or to perform other rescue duties prior to back-down. For 268 sets without towing, the statistics are:

<u>No. of speedboats in water to backdown</u>	<u>Average pre- backdown time</u>	<u>Analysis of covariance adjusted kill per set</u>
0 or 1 (114 sets)	68.45	12.88
2 or more (154 sets)	68.64	11.93

- (8) NMFS observers who have witnessed the use of speedboats by captains and drivers skilled in their use in towing on the net believe that this use is effective in reducing porpoise mortalities.

A drop in kill per set due to entrapment between 1975 and 1976 (Table 4) supports this analysis.

2.6.3 Effectiveness of the 2" porpoise safety panel

The 1976 regulations require that "a porpoise safety panel shall be installed so as to protect the entire perimeter of the backdown from the outboard end of the number three cork bunching line to the tiedown point. This panel must be a minimum of 100 fathoms in length, except that the minimum length of the panel in nets deeper than 10 strips shall be determined at a ratio of 10 fathoms in length for each strip that the net is deep. The porpoise safety panel shall consist of small-mesh webbing not to exceed 2" stretch mesh, extending from the corkline downward to a minimum depth equivalent to one strip of 100 meshes of 4-1/4" stretch mesh webbing" (*Federal Register*, 1975).

For the 1976 season a net diagram had been added to the observer set logs to record areas of individual entanglement of porpoise. An analysis of how many porpoise were entangled in each area of the net was not possible because in the data on some sets, only areas of entanglement

were noted (e.g., an "E" indicating entanglement might indicate that any number of porpoise were entangled in that area of the net). Four areas of the net were chosen for analysis: (1) the safety panel, (2) the 4-1/4" mesh outboard (ocean side) of the safety panel, (3) the 4-1/4" mesh under the safety panel and (4) the 4-1/4" mesh inboard (vessel bow side) of the safety panel. Of the 30 cruises available, 20 cruises and 154 porpoise sets had usable data for this analysis.

To determine the distribution of entanglement, statistics were computed showing percent of entanglement for each area in three ways (Table 11). The three methods (in the order they appear in the table below) are: (1) all notations of entanglement in an area were divided by total notations, (2) all notations of entanglement in an area were divided by total notations by trip and then averaged, and (3) the total of all "scores" for an area were divided by all "scores" (a score for a net area was registered if a net drawing had one or more notations of entanglement in that area).

<u>Method</u>	<u>Safety panel</u>	<u>Outboard of panel</u>	<u>Under panel</u>	<u>Inboard of panel</u>
1. Percent notations per area	51	21	23	05
2. Average of percents per area by trip	56	22	17	05
3. Percent of scores per area	53	17	21	09

Method 1 assumes all observers are equal and consistent over time in interpreting and recording entanglement. Method 2 assumes each observer is consistent over time but varies among trips; cruises with little entanglement are weighed equally with those having heavy entanglement. Method 3 assumes only that each observer records entanglement in each part of the net where he sees porpoise entangled. It is probably the best method for this analysis.

However, irrespective of which method is used, the data consistently indicate that many porpoise get entangled in the safety panel and relatively few get entangled on the vessel side of the safety panel. These percentages are not translatable into numbers of porpoise killed in the different areas mostly because entanglement is easier to observe in those portions of the net closer to the surface such as the safety panel. Of the 22 vessels with usable data for this analysis, the observers reported that 15 had 2.0" mesh, one had 2.5" mesh, three had 1.5" mesh and three had 1.7-1.8" mesh. The one vessel with 2.5" mesh is participating in the NMFS/industry cooperative gear test and is now equipped with a 1-1/4" mesh safety panel.

Findings in Section 3.3.4 of this report indicate that entanglement can be greatly reduced through the use of 1-1/4" mesh over a larger area of the backdown area than the regulations presently require.

2.6.3 The effectiveness of the backdown procedure in releasing porpoise

The 1976 regulations require backdown to be "performed following a net set where marine mammals are captured in the course of utilizing a purse seine for catching and landing yellowfin tuna . . . Backdown means a series of maneuvers which takes place after the net is tied down following a set and pursing, which keeps the net open to the greatest degree and allows porpoise or other marine mammals to leave the pursed net over the net floats which are submerged as a result of the vessel moving astern" (*Federal Register*, 1975).

An examination was performed of the effectiveness of backdown in releasing porpoise in 1976 (first 30 observed trips) and in 1975. The average number of porpoise released by backdown alone was 92.8 percent in 1975 and 97.0 percent in 1976. This represents a statistically significant improvement (Mann-Whitney U Test--taking the average of the cruises).

2.7 Possible Causes of the Apparent Decline in Kill Per Set

When so many factors interact in achieving reductions in the kill per set, it is difficult to isolate the sources of improvement. Nevertheless, analysis of the use of speedboats in reducing mortality demonstrated a six-fold increase in the use of speedboats to tow on the net in 1976 and a corresponding drop of about half in the incidence

of collapse and kill due to collapse. This apparently led to a drop in kill of about two animals per set. Therefore, towing with speedboats probably has accounted for about 60 percent of the 21 percent drop in standardized kill per set between 1975 and 1976.

The remainder of the drop in kill per set can be attributed to more effective use of rescuers and to more effective backdowns.

Malfunctions with delays while porpoise were in the net occurred in 19 percent of the sets in both 1975 and 1976. In both years malfunctions with net collapse occurred in 5 percent of the sets and contributed to about 14 percent of the kill in both years; there was thus no effect on the kill per set.

3.0 MORTALITY REDUCTION TECHNOLOGY

3.1 Introduction

In the past year, mortality reduction research and development continued to be concentrated primarily on what was termed "Phase One" activities by the Porpoise Committee (NOAA, 1972), that is, improvement, modifications, and supplements to existing purse-seine fishing technology. The research concentrated on physical mechanisms to reduce mortality when porpoise contact the net, to reduce the probability of contact, and to remove individual porpoise once netted. This is in contrast to more sophisticated electronic, chemical, or biological mechanisms which might prevent porpoise contact with the net ("Phase Two" activities). As stated in previous reports (DOC, 1974; SWFC, 1975) the research priorities are based on the resources available and the probability of success in the short term. However, longer-term sophisticated projects of the "Phase Two" type were initiated in FY 1976. In June 1976, a contract was let to the University of Hawaii to study the chemosensory abilities of yellowfin tuna and a research cruise in cooperation with the Marine Mammal Commission and Porpoise Rescue Foundation will begin in early October 1976 to study porpoise behavior (see Section 4.0, Porpoise Biological Studies).

The Mortality Reduction Task concentrated on the following developments during FY 1976:

- (1) the porpoise apron, an appendage above the safety panel;
- (2) the porpoise chute, an appendage above the apron;
- (3) finer-mesh webbing, in the backdown area;
- (4) speedboats to hold the net open;
- (5) porpoise rescue rafts;
- (6) the porpoise grabber, a handling device to aid manual removal of porpoises;
- (7) the large-volume purse seine;
- (8) rollup prevention; and
- (9) current indicator ribbons.

Work in these areas is aimed at alleviating previously identified major sources of mortality such as net collapse, creation of canopies, individual entanglement, and "sacking-up" operations (DOC, 1974). The first six items listed above comprise what is now known as the *Bold Contender* system.

During the fall of 1975, the Southwest Fisheries Center conducted two chartered gear research cruises using the 1000-ton IATTC yellowfin tuna allocation. Based on the results of testing the elements of the *Bold Contender* system on these cruises, a major testing program involving some 20 commercial fishing trips was initiated in cooperation with the tuna industry-sponsored Porpoise Rescue Foundation. This testing and evaluation program is referred to in later sections of this report as the joint NMFS/industry cooperative gear test.

In addition, the large-volume purse seine, the porpoise apron, anti-torque purse cable, rafts, and porpoise grabbers received additional testing through the cooperation, participation and investment of members of the U.S. purse-seine fleet. Descriptions and discussions of these tests are given in subsequent sections of this report.

An important function performed by members of this task is the evaluation of suggestions from fishermen and other concerned citizens on ways to reduce porpoise mortality. About half the suggestions are for ideas previously tested and found largely impractical, e.g., the net-in-a-net concept, the pneumatic porpoise escape gate, various uses of electricity, and sound emissions (e.g., killer whale sounds). Nearly all of the other ideas have reflected an unfamiliarity with the complexities of the purse-seining operation and the quantities and behavior of the animals involved. Some ideas, however, have led to gear modifications and some warrant further study. Figure 7 presents most of the concepts that have been tested to date.

Conclusions of each section of this report are summarized in Section 6.0.

3.2 The Use of Speedboats to Prevent Collapse

An overview of the use of speedboats in preventing collapse and loose pockets of webbing was given in the discussion in Section

2.6.2 of this report concerning the effectiveness of the speedboat regulation. The following discusses the results of the speedboat studies on the gear charters that took place in the fall of 1976.

During the fall 1975 charter of the M/V *Bold Contender*, speedboats were used either to actively pull adjacent bunchlines or were positioned at their assigned towing points until the vessel master determined that net collapse would not occur. Sets for active speedboat use or standby modes of operation were randomly selected prior to the cruise. The random pattern was followed during all but sets 25 and 31. Net collapse did not occur during the cruise although several sets required vigorous use of speedboats to prevent it. Both gear malfunction and poor wind and current conditions resulted in additional active use of speedboats for a total of 23 sets (*Bold Contender* Cruise Report, 1976).

During the fall 1975 charter of the M/V *Eastern Pacific*, whenever speedboats were available, at least two were positioned at towing stations adjacent to reversed bunchlines for use should the need arise. Use of speedboats to hold the net open was attempted only when collapse of the net was threatened by wind, current or gear malfunction. On several sets the speedboats were effective in preventing collapse. However, speedboats were not available during one net collapse due to multiple speedboat engine failures. Another net collapse occurred when the seine skiff engine failed and the wind blew the vessel across the net. After the net had collapsed around the seiner, the speedboats

were able to pull webbing free of the stern to allow backing the vessel around to more favorable wind and current conditions for hauling the net aboard. High porpoise mortality (approximately 50% of total mortalities) occurred during the two net collapses. Speedboats towing on the net to prevent collapse were very effective from all aspects including manpower requirements and gasoline (*Eastern Pacific Cruise Report*, 1976).

There were 10 sets on the two cruises where towing was optional (at the discretion of the captain) and two speedboats were used to tow on the net. One of these ended in collapse when the seine skiff engine failed (as noted above). These 10 sets have been combined with the 1976 data to show that early use of two speedboats towing from their sterns on bunchlines can prevent collapse in most cases.

3.3 *The Bold Contender System*

3.3.1 Background

Several factors and considerations led to the development of the *Bold Contender* system. Virtually every set made on porpoise schools by the U.S. tuna purse seine fleet employs the backdown procedure as described in last year's Progress Report (SWFC, 1975) to efficiently remove most of the captured porpoise from the net. Examination of this procedure identified several facets that could be improved by some modifications of the existing net. Problem areas are as follows:

- (1) The mesh size of the standard purse seine net (4-1/4" stretch mesh) and of the present porpoise safety panel (2" stretch mesh) allow considerable entanglement and resultant drowning of porpoise as they are forced into contact with the walls of the net during backdown.
- (2) Canopies of loose webbing often develop along the side walls of the backdown channel. Porpoises can become trapped and drown in these canopies during backdown.
- (3) Porpoise are occasionally forced toward the boat and away from the release area at the end of the backdown channel when tuna rise to the surface in that area. This not only makes it much more difficult to remove the porpoise but also greatly increases the fear of loss of fish on the part of the captain and tends to inhibit the backdown effort.
- (4) The amount of net that is in the water when backdown commences is critical to the success of porpoise removal. Unless a captain is aware of precisely the proper points to tie down his net for backdown, canopies (not enough corkline in the water) or folds of slack webbing and corkline (too much corkline in the water) will form and greatly increase the likelihood of an unsuccessful backdown.

The so-called porpoise apron was designed to alleviate these identified problems. The apron is a tapered, trapezoidal section of small-mesh webbing that is hung in the net with its center at the middle of the backdown area and laced in between the corkline and the top of the Medina panel (porpoise safety panel) (Fig. 8). Because of the apron's tapered sides, the webbing between the corkline and the bottom of the net at the apex of the backdown is longer than at the sides. This transfers the strain on the webbing from the center of the backdown area to its margins. Ideally, several desirable effects result. The deep, porpoise-entrapping pocket that commonly forms under the corks at the end of the backdown area tends to be eliminated. Instead, the panel and apron form a ramp that eases the porpoise over the corkline during backdown. It is therefore unnecessary to sink the corks to considerable depths with strong backdown surges, but rather a slow, continuous backdown can be performed.

The first prototype apron (2" mesh) was added to the net of the chartered purse seiner M/V *South Pacific* in the fall of 1974 with promising results. The *South Pacific's* captain transferred to another vessel and he requested and received 1-1/4" mesh webbing from which he cut and hung an apron in the net of his new vessel. A field technician accompanied that vessel; the promising results were discussed in the 1975 Progress Report (SWFC, 1975).

Subsequently, in the late spring of 1975 the American Tunaboat Association sponsored a workshop for captains and owners. At that time eight vessels volunteered to place aprons in their net, test them, and keep records on their performance. Two NMFS field technicians were deployed at this time. The results of interviews of captains who completed at least one trip with the apron are discussed in the 1975 progress report (SWFC, 1975). To date, 16 U.S. tuna purse seiners are known to be using the porpoise apron or modifications of it in their nets. NMFS personnel have been aboard eight commercial fishing trips and two charter cruises testing the apron. On a fall 1975 charter the M/V *Eastern Pacific* was outfitted with a 1-1/4" mesh single-depth, extended-length (180 fathoms) porpoise safety panel and a 1-1/4" mesh apron. The results of that charter and the other apron cruises are included in the apron analysis below. It is not known whether the apron modification is presently in use by foreign flag purse seiners.

3.3.2 Results of 1975-76 apron tests

Kill Per Set

The most important indicator of apron performance is the average kill per set which is best examined by eliminating sets in which this measure of performance is affected by factors not related to the test. Accordingly, for sets that had a backdown, only sets in which there was no net collapse prior to backdown and no gear malfunctions

while the porpoise were in the net are used in the present and several of the following analyses. These "normal" sets are stratified by the major variables affecting the kill, i.e., amount of tuna caught and by the number and species composition of the captured porpoise (Section 2.5).

Figure 8 depicts the various apron configurations that have been tested to date. According to the analysis of Coe (1976), the standard apron (apron and safety panel of 2" mesh) produced a kill per normal set (11.01) below the 1975 value for non-apron vessels (13.54) under standardized 1975 fishing conditions. The kill per set for the 1-1/4" apron used with the 2" safety panel (9.23) was about equivalent to the 1976 value for non-apron vessels (9.88) but the 1-1/4" apron on the 1-1/4" safety panel showed a very substantial decrease (3.64) under standardized conditions. All of the apron types show a decrease in average kill per normal set when compared to the same data from 1975 and 1976 non-apron cruises with the exception of standard 2" apron. Examination of data from cruises using the standard 2" apron reveals that two of the five cruises had repeated difficulty in achieving the proper tie-down points for effective use of the apron. This resulted in the formation of canopies during backdown and subsequent high kills. The analysis showed that the 1-1/4" mesh apron and safety panel achieved the lowest average kill per normal set (3.64).

Entanglement

The porpoise apron is installed between the corkline of the net and the top of the present 2" mesh porpoise safety panel, and effectively doubles the depth of the 2" mesh in the backdown channel. This increase in amount of small mesh was designed to result in a decrease in the incidence of individual entanglement of porpoise during and after the backdown procedure.

The standard 2" mesh apron shows a slight decrease in the incidence of individual porpoise mortality due to entanglement for each type of porpoise considered when compared to the same data for 1975 and 1976 non-apron cruises (Table 12). The kill per set due to individual entanglement shows a decrease for spotted and spinner porpoise when the 1-1/4" mesh apron is employed and an even greater decrease when the 2" porpoise safety panel below the 1-1/4" mesh apron is converted to 1-1/4" mesh. The incidence of individual porpoise entanglement in normal sets shows a clear decrease with increasing use of 1-1/4" webbing. This result is relatively independent of deployment or operational problems during backdown (Coe, 1976).

Entrapment

Compared to 2" mesh apron and non-apron cruises, the kill per normal set by entrapment is markedly lower for vessels that tested the 1-1/4" mesh apron atop either a 1-1/4" or 2" porpoise safety panel

(Table 13). The analysis indicates that in normal sets, the apron in conjunction with increased amounts of 1-1/4" mesh in the backdown area can effect a reduction of kill resulting from entrapment of porpoise in folds or canopies of net.

Loss of fish

When properly deployed, the porpoise apron forms a shelf or ramp at the backdown apex which continues to shoal as backdown proceeds, thus relying primarily on the weight of the porpoise to depress the corkline and effect their release. The shoaled area (in theory) inhibits the tuna from surfacing amid the porpoise and when the fish do surface they should tend to drive the porpoise onto the apron and over the corkline. With the porpoise effectively plugging the escape area and depressing the corkline by their weight, a smooth, continuous backdown rather than the normal stop-go/stop-go procedure is enabled. None of the eight captains interviewed in 1975 thought that the apron caused loss of fish, one stated that the apron helped slightly to prevent fish loss and two captains believed that the apron helped greatly in preventing fish loss.

Porpoise remaining in net after backdown

A stratification (to account for porpoise school type and quantities of porpoise and tuna captured) of the field technicians' estimates of the number of live porpoise left in the net after backdown

by apron type shows a general decrease in overall average "left-in" when compared to 1975 and 1976 non-apron data. Again, the vessel carrying the 1-1/4" mesh safety panel and apron showed the most improvement in this measure of backdown performance (Table 14).

Discussion

Virtually all of the chosen indicators of performance of the porpoise apron have shown a trend toward reduction of the problems of backdown outlined earlier. The indications are that the apron concept in conjunction with the increased use of small mesh (1-1/4") will result in the greatest reductions in porpoise mortality of all the gear tested. It is not possible at this time to determine the relative importance of either component in producing the trends shown here. The apron tests treated here have led to the development of the *Bold Contender* system and the ongoing NMFS/industry cooperative research program.

3.3.3 *Bold Contender* Charter Cruise

Due to the general success of the voluntary testing of the variations of the "porpoise apron" to improve backdown efficiency in 1975, NMFS gear specialists continued to refine the fine mesh and apron concepts by extending the length of the safety panel and making the panel and apron of 1-1/4" mesh. Such an apron and safety panel were placed aboard the chartered M/V *Eastern Pacific* and the results reported

above. In a concurrent test a sharply tapered piece of webbing was placed atop an apron, thus creating the apron-chute complex. The complex was placed atop a similarly lengthened, but double-depth, safety panel constructed of 1-1/4" stretch mesh nylon webbing (Figures 8 and 9) in the net of the chartered seiner M/V *Bold Contender* in the fall of 1975. During this cruise complementing methods and devices for reducing porpoise mortality were tested that included:

- (1) The use of speedboats to hold the net open as a preventative measure rather than a remedial one. (Work on earlier charters had shown that speedboats cannot effectively open an already collapsed net.)
- (2) A small-mesh (1-1/4") double-depth and extended-length (180 fathoms) porpoise safety panel (Figure 8).
- (3) A gently tapered small-mesh porpoise apron to reduce canopy formation during backdown and to form a shoaled area at the apex of the backdown area (Figures 8 and 9).
- (4) A sharply tapered small-mesh porpoise "chute" to accelerate water flow over the corkline, reduce the volume for containment of porpoise (forced evacuation) and in combination with the apron, accentuate the shoal area at the apex of the backdown channel (Figures 8 and 9).

(5) Continuation of backdown and rescue operations until all porpoise were out of the net.

(6) A small rubber life raft to allow its occupant to make sub-surface observation of the presence or absence of fish in the area occupied by the porpoise and to regulate backdown speed accordingly, and to assist in hand removal of any porpoise during and after backdown.

After six sets, during which the zipper concept (see below) and other objectives of the charter were being pursued and the captain and crew were learning to operate the apron-chute system, there were 25 sets made employing the above-described system. A zero kill was recorded for 15 of these sets and a kill rate of 1.44 porpoise per set was averaged for the 25 sets. Net collapses were completely averted by early deployment of from one to three speedboats to tow on adjacent bunchlines on 23 of the 31 sets under varying conditions of weather, current, and gear malfunctions.

The apron chute did not work perfectly. For example, when the net was pursed the added webbing in the backdown area tended to collapse into or out of the net causing folds which could lead to porpoise mortality when backdown commenced. However, it was found that a single speedboat could pull the apron-chute area into the proper shape just

prior to backdown with no difficulty. This was done on 11 of the last 25 sets without incident. Also, disproportionate loading along the corkline in the areas where the taper rate changed caused those areas to sink as backdown commenced thus requiring adjustment of a bow bunchline at the start of each backdown operation from sets 12 to 31.

3.3.4 Joint NMFS/industry cooperative gear tests

Upon completion of the charter cruise, the encouraging results were discussed with representatives of the tuna industry-sponsored Porpoise Rescue Foundation (PRF) and the Marine Mammal Commission. All agreed that the highest priority mortality reduction work should be to field test the *Bold Contender* system. The NMFS and the PRF jointly contributed funds to purchase enough 1-1/4" mesh nylon webbing to outfit 19 vessels--nine with the apron-chute complex and double-depth safety panel (*Bold Contender* system), and 10 with only a double-depth safety panel for the purpose of conducting a large field test of the new gear. All participating vessels carried SWFC gear technicians. The first trip of 1976 of the M/V *Bold Contender* carried a gear technician and by including this trip in the experiment, 10 trips of each system could be obtained. The major reason for designing the experiment in this manner was that questions had been raised as to whether the success of the *Bold Contender* charter was attributable primarily to the structure of the apron-chute complex or primarily to the use of the 1-1/4" mesh webbing, hence the division of vessels to test both concepts. Each vessel in the test was provided with a porpoise grabber, and a one-man rubber life raft,

a face mask and snorkel, and instructions on use of the raft as a porpoise rescue platform. The test was designed to evaluate any differences due to the apron-chute complex. To minimize variation and to maximize the probability of success of the experiment in either accepting or rejecting the apron, proficient skippers and well-maintained vessels were sought. Results are, therefore, not immediately applicable as expectations of how the fleet as an average might perform with either set of gear.

As of August 12, 1976, data were available from nine completed trips and six partial (aborted) trips. Radio contact with SWFC gear technicians and captains aboard two vessels still at sea has provided additional information.

The gear test was partially interrupted by the May 11 order of Federal Judge Charles Richey to cease porpoise fishing as of May 31 and the experimental design was severely compromised. Six NMFS technicians were put ashore during the period of uncertainty as to the final disposition of the court order. The effect was differential with regard to the two systems--primarily affecting the vessels testing the fine-mesh-only system. The placement of fine-mesh-only systems was also behind the schedule of placing the *Bold Contender* systems which compounded the problem. The unexpected paucity of data makes much necessary analysis difficult or impossible at this time, because different times, areas, and porpoise species are being fished by the test vessels as a result of the interruption. Moreover, data from one of the vessels using the

fine-mesh-only system were found to be useless as the gear was not used in the manner prescribed. The fine mesh was installed for use with the pulling of three bunches but only two were pulled during the cruise. This resulted in extensive areas of 4-1/4"-inch mesh net in the backdown area and an abnormally high kill rate. Data from that vessel have thus been excluded from this preliminary report and provisionally from further analysis. However, one vessel using the *Bold Contender* system suffered a net collapse prior to backdown, resulting in high mortality, and its data are included. The kill in that set is about one-third of the *Bold Contender* system total and nearly twice that encountered by any other gear technician or observer trip in 1976.

Simply as a matter of interest, after pooling the preliminary data from all sets and all available information, the *Bold Contender* system has produced a porpoise kill per set of 6.1 and the fine-mesh Medina panel has produced a kill per set of 7.6. These rates, while not strictly comparable, are considerably lower than the 1976 fleet average which as of June 30 stood at 12 porpoise per set. Kill per ton data showed the fine-mesh panel system at about half the fleet average (0.5) and the *Bold Contender* system about one-third the fleet average (0.3). Figure 10 shows the kill-per-ton statistics for the 1975 and 1976 Observer Program trips and the two experimental systems. While this information is interesting, any comparison must consider the type of porpoise school and the amount of porpoise and tuna captured. Data presently available only allows such comparisons for the *Bold Contender*

and 1976 observer trips. The fine-mesh-only system data on hand consist of one outside-CYRA trip, one trip with probably unusable data, and one complete and three partial trips inside the CYRA. Information in this report presented for these six cruises can be considered only an indicator of the performance of the fine-mesh-only system. The vessels at sea will have more than half the usable data for this system. The *Bold Contender* data consist of seven complete and two incomplete trips (all inside the CYRA) and is considered sufficient for certain comparisons with the 1976 observer trips. It must be kept in mind that because of the selection of proficient participants the comparisons between observer and experimental cruises cannot be used to draw definite conclusions. While the amount of bias due to having mostly proficient participants is unknown, the results of the *Bold Contender* system reported below are considered to be very promising for porpoise mortality reduction. The experiment is still in progress and definitive conclusions cannot be adequately supported at this time.

Captain interviews

Whenever possible, captains of test vessels have been interviewed on completion of their trips. Two captains still at sea have also discussed (by radio) their opinions concerning the test gear. The following comments were received:

Bold Contender system

- 8 thought the gear greatly reduced mortality
- 1 thought the gear moderately reduced mortality
- 1 thought the gear did not help and actually hindered his operations

Fine-mesh only system

- 2 thought the gear greatly reduced mortality
- 1 thought the gear did not help to any degree
- 1 thought the gear hampered his operation a great deal

Individual entanglement

In preliminary data, for sets involving kill of porpoise, the *Bold Contender* system shows a four-fold decrease in kill due to entanglement (2.1 per set) when compared with the 1976 non-experimental cruises (8.9 per set). The fine-mesh-only system (including one cruise outside the CYRA) produced a higher average kill per set due to individual entanglement (4.6 per set) than the *Bold Contender* system though still below the value for the non-experimental cruises. This is supported by an analysis involving counting the notations of entanglement on the net diagram in the observer set logs. Assuming that the count of noted entanglements ("E's" in the set log) is at least a relative measure of the amount of entanglement during a set, the following table can be used as an indicator of whether or not a reduction in entanglement occurred.

	<u>No. of porp. sets</u>	<u>Count of E's</u>	<u>E's per set</u>
1976 observer trips	425	581	1.37
Fine-mesh-only system*	132	73	0.55
<i>Bold Contender</i> system	200	41	0.21

*One outside-CYRA trip included.

The four strips of 1-1/4" mesh webbing (versus two strips for the fine-mesh-only gear and one of about 2" mesh for the regular gear) at the backdown apex, where the captured porpoise most often come in contact with the net during backdown, is the probable reason for less entanglement in the *Bold Contender* system.

Entrapment

The apron-chute complex in the *Bold Contender* system was designed to alleviate folds and canopies of webbing during backdown as discussed earlier. The incidence of canopies during backdown is 16 percent for the *Bold Contender* system and 19 percent for the fine-mesh-only system. These data were not collected on regular observer cruises.

Based on the *Bold Contender* charter experience, captains of vessels that carried the *Bold Contender* system were briefed before sailing on the propensity for the apron-chute to collapse during net hauling operations before backdown and the necessity of occasionally using a single speedboat to open or adjust that area prior to commencing

backdown. The set logs and some interviewed captains have indicated that this is still a problem. Speedboats have been used on 19 percent of the *Bold Contender* sets to adjust the backdown channel prior to backdown. Speedboats have been used in a similar way on about 5 percent of the fine-mesh-only sets.

On sets involving kill of porpoise, the 1976 observer trips show a kill due to entrapment of 8.1 per set compared to 8.7 for the *Bold Contender* and 11.2 for the fine-mesh-only system (includes one cruise outside the CYRA). Omission of the one set (previously discussed) involving major collapse reduces the *Bold Contender* value to 4.3 for kill per set due to entrapment.

Loss of fish

The apron chute is designed to provide a ramp at the backdown apex which will sink under the weight of the porpoise but will be shallow enough to turn most of the tuna away from the release area (Figure 9). With this configuration, the net forms a deep pocket closer to the main vessel where the tuna tend to congregate until the net is completely stretched out during the latter stages of backdown. Ten skippers that tested the *Bold Contender* have been interviewed and six felt the system helped prevent fish loss, two felt that it made no difference and two reported moderate-to-severe loss of fish during initial sets.

The fine-mesh-only system produces a sub-surface shape in the backdown channel that is similar to the conventional procedure. This type of backdown has a near-vertical wall at the backdown apex and fish can surface in the midst of the porpoise at the release area. When this happens the porpoise are driven back into the net and backdown must stop for fear of loss of fish. Six captains who tested the fine-mesh-only system were interviewed; three felt that the gear did not help to prevent loss of fish, one felt that it helped slightly, and two reported no difference.

Both systems tended to sink in the early stages of backdown. The *Bold Contender* system showed sinking along the apron taper and at the junction of the apron and chute. Adjustment in the taper or an increase in flotation along the apron taper is thus indicated as a means to eliminate this cause of fear of loss of fish. The fine-mesh-only system was found to create an increase in the tendency of the corkline to sink during backdown to the extent that interviewed technicians estimated that approximately 40 to 45 tons of tuna were lost in six cruises. In describing the problems encountered with this system, three of the five technicians felt that not enough reverse power could be applied to release the porpoise effectively and still not risk losing fish. Three captains felt that this gear did not make backdown easier for them. One captain who used the gear successfully used a technique of picking up extra purse rings before backdown. This reduced the strain on the corkline during backdown and reduced or eliminated sinking problems.

Hand release of porpoise

In a great many sets there are porpoise that cannot or will not be backed out of the net. These "left-in" animals and those that become entangled or entrapped before and during backdown must be rescued individually by crew members either from a speedboat or by swimming in the net. Sharks are often present inside and outside of the net during porpoise sets, thus making hand release of animals dangerous, particularly to crewmen swimming in the net in pursuit of porpoise. The raft was introduced as a means of allowing the rescuer mobility similar to a swimmer and at the same time not exposing him to possible shark attack.

A small one- to two-man rubber life raft was provided to each vessel in the test under the loan agreement and the captain was instructed in its use. During the captains' interviews, mixed opinions were received concerning use of the rafts. About half the skippers indicated the raft to be useful and the other half could see no advantage or did not plan to use it in the future. Most felt that occasional occurrence of sharks in the net did not present any problem to rescuers using rafts.

Porpoise left in net after backdown

The number of porpoise left in the net after backdown is significantly less (Wilcoxin matched-pairs signed-ranks test) for the

Bold Contender system (5.3 per set) than the first 30 observer trips of 1976 (15.9 per set). The fine-mesh-only data (including one trip outside the CYRA) show 11.5 porpoise per set left in the net after backdown.

Corkline color change

Behaviorists working with various species of porpoise in oceanaria have often observed that captive animals show less avoidance response to dark-colored objects than to brightly-colored objects in their tanks. For this reason, approximately 10 fathoms of the yellow, white- or red-colored floats across the backdown apex of nets of six of the participating vessels were spray painted flat black. When asked if the black-painted corks had any effect on porpoise release, two captains and five technicians replied negatively. Three captains and one technician said they did not know. Though there may be some effect, it has not been observable due to the complexity of the stimuli that are operative during backdown.

Standardized kill per set

All *Bold Contender* system data that will be collected on trips inside the CYRA in 1976 have been collected with the exception of two research charters planned this fall. The *Bold Contender* system kill per set data for sets with porpoise captured and without collapse or malfunctions ("normal sets") were compared with similar 1976 Class III

observer trips and the available fine-mesh-only system data including the one trip outside the CYRA. The data were categorized for amount of tuna and porpoise and porpoise school captured (Table 15). In the eight categories, the *Bold Contender* kill per set, when compared to the observer cruises, is at least 50 percent lower in seven and 33 percent lower in the other. The fine-mesh-only system is also lower in the seven categories with data. The *Bold Contender* system when used in conjunction with the test vessels had a kill per "normal set" which when standardized to 1976 observer trip fishing condition categories (as in Section 2.5) was 5.3 per set versus 10.8 for the 1976 observer trips. When all sets are included the *Bold Contender* system, when standardized to 1976 fishing conditions has a kill per set of 7.7 compared to the Class III vessel kill per set of 13.2. Assuming no bias through selection of participants and different time and area strata, the differences are statistically significant for both "normal" and total sets (Wilcoxin matched-pairs signed-ranks test).

It is inappropriate to do such an analysis for the fine-mesh-only system because of insufficient and perhaps different (one trip outside the CYRA) data. In any case, the present data show no statistically detectable difference in kill per set between the two experimental systems.

The percent of sets with zero porpoise killed is summarized as follows:

<u>Trip type</u>	<u>All porpoise sets</u>	<u>Porpoise sets with porpoise captured</u>
1976 observer	40	31
Fine-mesh-only (one trip inside CYRA)	50	44
<i>Bold Contender</i>	56	54

The data indicate a better capability for vessels using the experimental systems to achieve sets which kill no porpoise.

Discussion

All of the data from the 20 cruises participating in this joint NMFS/industry gear test will not be available until late fall of this year and until that time it would be premature to draw any more than "rule-of-thumb" conclusions in comparing the two systems with each other. However, sufficient data are available to compare the *Bold Contender* system cruises with non-experimental cruises for the purpose of obtaining additional "rule-of-thumb" conclusions. It is recognized that the experiment was not designed for this comparison and any comparison may be biased to some unknown degree by the experimental design itself. Therefore, caution is needed in interpreting the findings in that the participating vessels were not selected randomly and therefore do not necessarily represent what the overall U.S. purse seine fleet might do with the tested gear. Further, Judge Richey's decision has resulted in an unexpected delay of the experimental cruises and insufficient

data for determination of differences between the two experimental gears--at least at this time. Should there be a significant difference between the two gears, then the conclusion would be that the better system will also reduce the average kill rate significantly for the fleet.

The problems encountered in using the *Bold Contender* system such as sinking along the apron taper and at the junction of the apron and chute, collapse of the apron-chute area during net hauling and small canopies in the chute apex during backdown appear solvable through adjustment or augmentation of flotation, speedboat towing, and modification of the hang-in rate along the corkline above the chute, respectively. Solutions to these problems by refinement of the structure of the apron-chute will be pursued in a charter cruise in the fall of 1976 and by adjusting gear aboard participating vessels in the gear study. Prior to this mass test of the *Bold Contender* system it was felt by some industry representatives that the restriction of having to tie the net down for backdown at precisely the same place each set would cause difficulties in sets with large amounts of fish and porpoise captured. This was not mentioned as a problem by nine of the captains interviewed that tested the *Bold Contender* system; sets were made with up to 6000 porpoise captured and up to 90 tons of tuna with no mortality and no fish lost. It is quite likely that being required to tie down at the exact same points on every porpoise set reduces the problem of canopies caused by malformed backdown configurations when the tie-down point is variable.

Two vessels that tested the *Bold Contender* System have recently changed the rate of taper in the chute to the same as the apron (five mesh, two bar) in an attempt to reduce the severity of sinking at the junction of the apron and chute. The vessels sailed to the fishing grounds as this was written and results of the modification will not be available until near the end of 1976.

The major problem with the fine-mesh-only system appears to be the inability to backdown fast enough to release the porpoise and not risk loss of fish. The corkline often sinks too fast and rises too slow for an effective backdown. Increases in the amount of flotation along the backdown channel through installation of recently available oversize corks may be a workable solution.

One of the vessels testing the fine-mesh-only system requested removal of part of the gear due to the sinking problem but has since converted to the full *Bold Contender* system. Radio reports from this vessel indicate improved porpoise removal but a continuing sinking problem and the loss of 30 tons of fish.

The large-scale joint NMFS/industry approach to research on the problem of incidental porpoise mortality is a logical and productive way to combine the resources and ideas of both communities. It should be continued as long as advancements in mortality-reduction technology

can be realized. Because of the severe disruption of the experimental design and the unexpected lack of data suitable for comparisons between the two test systems (e.g., nine of 10 *Bold Contender* systems were tested inside the CYRA while almost all the usable fine-mesh-system data will be from outside the CYRA with different porpoise, numbers of porpoise, weather, etc.), further testing of both systems is necessary and certain improvements discussed above should be made before any conclusions can be drawn as to system differences; nevertheless, preliminary results are very encouraging in that they tend to indicate that both systems have the potential to significantly reduce porpoise mortalities. Supportable conclusions must await sufficient data to permit standardization to comparable conditions of fish and porpoise school sizes and types of porpoise schools. We expect to have obtained sufficient data for analysis by the end of 1976.

3.4 Rollup Prevention Research

3.4.1 Anti-torque purse lines

In 1973 experiments were initiated to develop a system capable of preventing a common gear malfunction called "rollup." In a rollup, the purse cable turns and winds up webbing. This sometimes interrupts the normal routine of purse seine fishing operations and indirectly contributes to incidental porpoise mortality. This occurs whenever a

time delay coupled with adverse current and other factors results in collapse of the net prior to backdown. In most cases there is a delay which increases the risk of net collapse. In some rare instances, rollups cause extensive ripping of the net, loss of fish, and entanglement of porpoise in canopies of loose webbing during backdown.

In 1975 rollup-caused delays occurred in 5 percent of all sets (SWFC, 1975). In 1976 they occurred in 31 of 425 sets, or 7 percent of all sets. The average kill per set in a rollup set was 19.4 in the first half of 1976 and the average delay was 39 minutes. All sets with rollup involved delay. Because the kill per set in sets without rollup was 11.4 and the kill per set in rollup sets was 19.4, we estimate that an average of eight porpoise were killed in a rollup set due to the rollup. Since this occurred in 31 sets, about 248 porpoise, or 5 percent of the total kill (5132) in 425 sets was due to rollup.

Early experiments using torque-balanced wire rope purse lines indicated that frequency and severity of rollups could be reduced. Anti-torque characteristics of a new-type purse line substantially reduced a tendency for rotation under load that was common in conventional purse line.

Results of these initial tests led to installation (in 1974) of torque-balanced purse lines by the owners of seven tuna seiners.

However, a design change in the wire rope construction specifications (to make it more flexible) resulted in sub-normal performance and eventual replacement with conventional purse line on these seven vessels. In contrast, the original purse lines installed on two test vessels in 1973 are still in use. Although skippers of these two vessels report that rollups still occur, they believe them to be not as frequent or as severe as would normally be expected from experience with conventional purse lines on these particular vessels. Data for comparisons are not available, however.

3.4.2 Anti-rollup purse block

In an attempt to further reduce or eliminate incidence of rollups that can occur even with torque-balanced wire rope, a new study was begun in 1976. The study involves development of a purse block suspension system capable of minimizing the induction of turns into the purse line caused by the weight of the block not allowing the cable to run in the center of the block's pulley. A contract has been let to study the problem and make recommendations of options that may be available utilizing off-the-shelf technology.

Preliminary evaluation of the contractor's progress is that an acceptable design has not been achieved.

3.5 Large-Volume Purse Seine

We have continued work on the large-volume net described in previous reports (DOC, 1974; SWFC, 1975). This net provides a larger volume of water than the standard purse seine to permit it to safely contain large catches of fish and porpoise. The porpoise safety panel has 1-1/2" mesh and the net is tapered to reduce canopies and pockets of loose webbing. Early results showed a kill of 4.97 porpoise per set and a kill per ton of tuna of 0.27 (SWFC, 1975).

During 1975 the experimental large-volume purse seine underwent major modification in an attempt to improve its practicality and acceptability. An additional 100 fathoms in length were added to the net's mid-section. Braided nylon ring bridles were replaced with conventional galvanized chain. Main bunt rolling strips were replaced with heavier webbing to allow handling larger catches without loss of fish due to rips and tears. The mid-net cutting zipper was also removed after repeated fouling contributed to formation of canopies resulting in porpoise mortality.

In July and August 1975, the net was tested during commercial fishing west of the CYRA. Test results gave a porpoise mortality rate (per ton of tuna) of about double the fleet average and an approximate 30 percent increase in kill per set. The cruise was terminated prematurely due to a mass protest of American vessels against foreign

vessels allegedly fishing within the closed CYRA (virtually all American vessels ceased fishing and returned to port during the protest action).

Following the protest, a second attempt to test the gear was precluded due to an engine room fire aboard the test vessel shortly after arrival on the fishing grounds. After extensive repairs, the vessel resumed fishing but made no sets on schools of yellowfin associated with porpoise.

The principal operational problems reported by the skipper and deck boss of the vessel include:

- (1) Excessive tendency to collapse following modification of net length from 602 fathoms to 702 fathoms.
- (2) Deterioration of the 8" leadline selvage strip and adjacent 24-thread bottom strip required frequent repairs; replacement of those strips is needed.
- (3) General shrinkage of nylon webbing throughout the net without corresponding shrinkage of Dacron corkline required frequent stopping of net hauling operations to gather up excess corks to prevent rolling catch of fish over corkline.

- (4) Disproportionate shrinkage of adjacent strips of webbing caused excessive bags and pockets of webbing.
- (5) Insufficient depth of net at 1/4 and 3/4 net caused loss of fish during schoolfish sets.
- (6) The mid-net bunt and rolling strips were inadequate to handle large catches.

The net was inspected during removal of the gear from the boat. Estimated cost for needed modification and repair is approximately \$45,000. The work will involve complete disassembly of the net and rebuilding to desired configuration and strength. A decision on whether to pursue the large-volume concept and repair the net must await results of the ongoing Government/industry cooperative gear tests.

3.6 The Zipper System

During the early part of the *Bold Contender* charter cruise in the fall of 1975, a ring and drawstring "zipper system" was tested. The intent of the idea was to separate the porpoise and tuna by a vertical wall of webbing during porpoise-removal operations in order to preclude loss of fish and enhance removal of porpoise.

The zipper system consisted of a series of 3" steel rings attached to the apron starting near the edge of the chute at 1-1/2-fathom intervals down the bar to the base of the safety panel, along the bottom of the panel and then up the bar to the other edge of the chute at the corkline. The rings were threaded with 3/4" braided rope with attachment eyes on either end. Prior to backdown, a speedboat was used to haul sections of 1" polypropylene rope from the bow and afterdeck for attachment to the zipper line ends. The lightweight rope and quick-release snap hooks allowed speedy (less than 2 minutes) deployment of haul lines. The main winch aft and the bow-mounted cork pursing winch was used to pull the zipper. Excessive drag of webbing caused severe overload of the haul lines and zipper line. However, the system was activated partially on three sets and completely on one set. During the partial cuts, folding of webbing occurred and porpoise were observed under folds but not entangled. During the one complete cut with the zipper, the corks would not sink even when additional backdown power was applied. This required removal of a great number of porpoise by hand. Severe chafing of the zipper line caused it to part on the fifth set. The zipper line was then removed and further experimentation terminated. Work on this concept has been terminated because extensive mixing of porpoise and tuna was observed on several sets and the technical problems may not be solvable.

3.7 Use of Ribbons as Current Indicators

Testing of current ribbons continued in FY 1976. The indicator consists of a fluorescent ribbon with a float at one end and a weight at the other and is designed to indicate subsurface currents by unwinding from the floating storage spool. Sinker weights, flotation, and ribbon lengths were increased with inconclusive results. The concept does not appear to be useful due to excessive time for deployment, erroneous indications of current direction, and the formation of huge loops and swirls. Further work on this concept has been suspended.

3.8 Porpoise Grabbers

Several different styles of porpoise grabbers were tested during FY 1976 and each of the cooperative gear test vessels has one on board. The porpoise grabber most closely resembles a long-handled shepherd's crook and is used to guide porpoise out of the net or to reach entangled animals that are out of arm's reach. The large spring-loaded porpoise grabbers mentioned in last year's report (SWFC, 1975) have given way to a single ball-covered prong. The large grabbers were found to be too cumbersome to be effective. In addition, those with two prongs often got caught in the net. Several different shapes are still being evaluated.

3.9 Plans for Research in Mortality-Reduction Technology

Program emphasis in the fall of 1976 and spring of 1977 will lie in evaluating the results of the present cooperative gear test and in working at the problem areas encountered by the *Bold Contender* and fine-mesh-only systems. While we believe most, if not all, of the *Bold Contender* system's problems currently reported to us are solvable, it is important to be able to demonstrate this and also to demonstrate any differences between the two experimental gears. A gear charter cruise will be made during October and November of 1976 to resolve several of the problems encountered in the *Bold Contender* system. However, further gear technician trips will be needed to resolve the problems and refine both concepts to their full potential.

In addition, the use of rafts as porpoise rescue platforms, conditions that lead to "disaster sets," the effectiveness of porpoise grabbers, and the role of malfunctions in causing porpoise mortality will be investigated more completely. Rollup-prevention research will also continue through evaluation of alternative purse-block designs, further analysis of anti-torque cable and identification of problems on those vessels having above-average incidences of rollup.

Further research based on the Phase II studies (sensory and behavior research) initiated this year will be planned as promising and applicable results are obtained.

4.0 PORPOISE BIOLOGICAL STUDIES

In FY 1976 the work of the Porpoise Biological Studies Task centered on developing and refining life history information for the species of porpoise involved in the yellowfin purse seine fishery. The concentration of work has been on those species and stocks most heavily involved. Work on the lesser-involved species and stocks has been limited to receipt and cataloging of specimens for future analysis.

The output of this task is most directly used in stock assessment and studies of the impact of the incidental kill on the porpoise stocks. The output includes identification of the species and stocks (systematics), reproductive rates, feeding habits and other life history information. The continuing behavioral work that is receiving increased emphasis is also a responsibility of this task.

Much of the basic life history information has been developed for the offshore spotted dolphin (*Stenella attenuata*) and the eastern form of spinner dolphins (*Stenella longirostris*). Work has progressed sufficiently to allow a shift to a monitoring status on these two stocks and a speedup of work on the striped dolphin (*Stenella coeruleoalba*) and the whitebelly form of spinner dolphin. In addition, a contract has been let to the Naval Undersea Center (NUC) for cataloging, processing, and analysis (joint with SWFC) of specimens of the common dolphin (*Delphinus delphis*). A useful summary of life history information for five species is presented in Table 16.

One of our difficult problems, direct calibration of age, is receiving special attention through a continuing contract with Dr. Jeffrey Bada of the University of California at San Diego. Dr. Bada is applying his new technique of aging mammals through racemization analysis of proteins. On the first contract, Dr. Bada found that there was too little enamel on porpoise teeth to support analysis but has recently found alternative methods with tooth dentine and possibly eye lens proteins. He is presently applying these alternative methods to specimens of *Stenella attenuata* and *Tursiops truncatus*.

We have also recently issued bid invitations for the sectioning and reading of growth zones of about 24,000 teeth from 8,000 spotted dolphins. The data from this analysis will be used to estimate age structure of the incidental kill and total mortality rates.

Plans for this Task for the next 12 months include:

- (1) Preliminary processing and cataloging of incoming specimens.
- (2) Continued work on the whitebelly spinner dolphin, striped dolphin, and the common dolphin (in cooperation with NUC).
- (3) Continuation of porpoise behavior studies, with initiation of a project in cooperation with NUC, the Marine Mammal Commission, the University of California at Santa

Cruz, San Diego State University, and the Porpoise Rescue Foundation. The San Diego State and NUC participation is being supported by the National Science Foundation through its RANN (Research Applied to National Needs) Program.

- (4) Continuation of work on systematics of *Stenella* spp., in collaboration with an international group of specialists.

The following pages of this section report on the work completed during the last year in developing the biological parameters of the eastern and whitebelly spinner and striped dolphins. The offshore spotted dolphin results presented in abstract form in last year's progress report have been published (Perrin, Coe, and Zweifel, 1976). A more recent report on this species (Perrin, Miller, and Sloan, 1976) presents an analysis of additional samples collected in the 3 years from 1973-1975. A significant development in the update is estimation of the gross annual reproductive rate with two methods. The first is based on the reproductive structure of the sample of adult females, with the assumption that the samples are not biased with respect to reproductive phase, i.e., the proportion of a sample of mature females in a particular phase in the sample is directly proportional to the length of that phase (with the length of gestation, 11.5 months for a time calibration). The second method is based on the estimate of length of gestation and a largely independent estimate of length of lactation. The gross annual

production of calves for 1973-1975 is estimated at 10.7% under the first method and 13.2% under the second. The balance of evidence seems to favor the estimates based on the second method, which tends to show relatively stable annual pregnancy and gross annual reproductive rates.

The conclusions of each section of this report are summarized in Section 6.0.

4.1 Biological Parameters of Eastern Spinner Dolphin

We reported last year on some preliminary results of an extensive study of the growth and reproduction of eastern spinner dolphins, a geographical form of *Stenella longirostris* in the eastern tropical Pacific (Perrin, Holts, and Miller, 1975). That study is now completed, and the results (Perrin, Holts, and Miller, 1976a) are summarized below.

- (1) Average length at birth is 77.0 cm.
- (2) Gestation period is 10.6 months.
- (3) Average length at 1 year is approximately 134 cm.
- (4) Three alternative hypotheses of rate of deposition of dentinal growth zones are:
 - (a) 1.5 zones per year throughout life,
 - (b) 1.5 zones in first year, one per year thereafter (most favored hypothesis), and

- (c) 1.5 zones until puberty (at 5.5 zones in females and 9 zones in males) and one per year thereafter.
- (5) Males attain sexual maturity on the average at about 170 cm (range 160-195) and 9-12 zones (6.0-11.5 years), depending on the criterion of testis-epididymis weight chosen. Average length at attainment of social maturity is unknown.
- (6) Average length of adult males is 174-176 cm.
- (7) Females on the average attain sexual maturity at 165 cm (5.5 zones; or 3.7, 5.0, or 3.7 years under Hypotheses I, II, and III).
- (8) Average length of sexually adult females is 171 cm (range 152-187).
- (9) Ovulation rate is one per growth zone (one per 0.67-1.00 year) until about 10 ovarian corpora have been accumulated, after which the rate declines.
- (10) Approximately 1% of adult females are postreproductive.

- (11) Estimates of annual pregnancy rate (APR) vary depending on the methods employed in calculating the average length of lactation period (see Section 4.0). Method 1 as described for spotted dolphin indicates the APR as 37.5%, 34.4%, 24.3%, 44.4%, and 38.0% for 1971, 1972, 1973, 1974, and 1975, respectively. The pooled estimate for all years' data is 36.0%. Method 2 as discussed for spotted dolphin indicates the rate to be 45.0%, 47.4%, and 45.9% for 1973, 1974 and 1975, respectively. The pooled estimate for all years' data is 46.1%. The corresponding estimates of calving interval ($1/\text{APR}$) using Method 1 for the same respective years are 2.66, 2.91, 4.12, 2.25, and 2.63. For the years pooled the estimate is 2.78. Method 2 estimates for the same respective years are 2.22, 2.11, and 2.18, for a pooled estimate of 2.17 years.
- (12) Pregnancy rate decreases after an age of about 12 zones (8.0, 11.5, or 10.2 years) concomitant with increase in lactation rate.
- (13) Overall sex ratio for the population is near parity, but there are about 6% more females than males in adults.
- (14) Estimates of gross annual reproductive rate can be calculated based on the two methods of estimating pregnancy

rate. Method 1 yields rates of 5.4%, 9.6%, and 8.7% for 1973, 1974 and 1975, respectively, for a 3-year pooled rate of 8.0%. Method 2 yields rates of 9.9%, 10.3%, and 10.5% for the same respective years, with a pooled rate of 10.2%.

4.2 Biological Parameters of Whitebelly Spinner Dolphin

Perrin, Holts and Miller (1976b) have reported on some preliminary estimates of growth and reproduction of the whitebelly spinner dolphin, a geographical form of *S. longirostris* in the eastern tropical Pacific. While the results are preliminary, they are based on large samples, and we do not expect that major changes in the estimates of the parameters will occur in the final version of their study, aside from Method 2-type calculations of pregnancy rate and gross annual reproduction. The authors estimate that:

- (1) Average length at birth is 77 cm.
- (2) Gestation period is 10.6 months.
- (3) Average length of males at attainment of sexual maturity is not known at this time. The average length of adult males is 179-182 cm (range 160-200 cm).

- (4) Average length of females at attainment of sexual maturity is 169 cm. Average length of adult females is 175 cm (range 161-196 cm).
- (5) Approximately 1% of adult females are post-reproductive.
- (6) Estimates (Method 1) of annual pregnancy rate range from 35.7% (based on 1973 data), 32.9% (based on 1974 data) to 47.8% (based on 1975 data). The pooled estimate for all years' data is 41.4%. The corresponding estimates of calving interval (reciprocal of pregnancy rate) are 2.80, 3.04, 2.09 and 2.42, respectively. Method 2 calculations are not yet available.
- (7) The overall sex ratio for the population is 1.03 males: 1 female. In adult-size animals the ratio was 0.96 males:1 female.
- (8) The gross annual reproductive rate (Method 1) based on the 1973, 1974 and 1975 data are 9.3%, 9.9%, and 12.2%, respectively. The estimate based on pooled data for the 3 years is 11.0%. Method 2 calculations are not yet available.

- (9) The proportion of females reproductive is stable over the last three annual samples, at 54%.

Table 17 presents a summary and comparison of selected biological parameters of the eastern and whitebelly spinners.

4.3 Biological Parameters of the Striped Dolphin

Kimura and Perrin (1976) have reported on the progress of activities to date on various aspects of the biology of the striped dolphin (*S. coeruleoalba*) also called "streaker dolphin" and "blue-white dolphin" in the eastern tropical Pacific. The report discusses the activities in investigating such parameters as distribution, morphology, growth, reproduction and ecology with emphasis on life history. An extensive literature search of the biology of the species has been completed and is appended to their report.

Aside from the literature search, Kimura and Perrin have initiated preliminary research on the striped dolphin. They believe that the dolphin as a species may range continuously from the eastern tropical Pacific to Japanese coastal waters. There also seems to be a break in their distribution between 10° and 17°N latitude in the eastern Pacific suggesting a possibility of more than one stock. This will be further investigated when the specimens from each area are examined.

To date, 91 specimens have been collected from 1973-1976. These samples are being examined for length-frequency distribution and age determination through tooth sectioning and reading. Testes are being weighed and samples prepared for histological examination to study male reproduction. Ovaries are being analyzed for reproduction capabilities. Stomach samples are being analyzed to determine feeding habits. Various organs are being studied for physiology and systematics of the group as well as parasitism. The results of these studies will be made available in a future report.

4.4 Behavioral Studies

An analysis of indices of behavior has begun from the data collected by observers (length of chase, percentage of school captured, etc.) in relation to history of fishing, by 5° area. If the data base is adequate, and if avoidance learning has occurred in the dolphin populations, correlations should emerge. This work will continue in FY77, and the large-scale cooperative field study described above will begin in October 1976.

5.0 PORPOISE STOCK ASSESSMENT

The Stock Assessment Task has two major responsibilities. The first is the quantitative estimation of the abundance and distribution of the various porpoise stocks. The second is the determination of the effects of fishing for tuna associated with porpoise on the abundance and distribution of the stocks. The status of the stocks will be addressed in a separate report (SWFC, 1976) since a stock assessment workshop was being held concurrently with the writing of this report. This section will therefore be limited to a discussion of the supporting activities of the past and coming year. The conclusions of each section of this report are summarized in Section 6.0.

5.1 Aerial Survey

A request for funding to support an aerial survey in FY 1977 was eliminated from the President's budget during Congressional deliberations. Although the base program cannot support an aerial survey (estimated at \$350,000-500,000 depending on aircraft availability), it is still possible that sufficient funding will be obtained for a full-coverage survey. We have been proceeding on a low-priority basis with preparations for an aerial survey in order to be ready when and if funding is obtained.

Working in cooperation with the Fisheries Engineering Laboratory of the Southeast Fisheries Center, we conducted photographic tests in May 1976 over local Southern California porpoise populations in a study aimed at determining the best type of film and the proper camera settings for filming porpoise schools from an aircraft. This study was in preparation for a larger study that is to be conducted on the fishing grounds off Central America in 1976. This planned 10-day study is aimed at determining the best procedures for use during the full survey, e.g., how many times should an aircraft circle the porpoise school, should the aerial observers record results individually or by group consensus, how should the cruise track be scanned and how can photography best augment visual sighting records. Necessary clearances are being obtained.

A second major part of the study is to compare visual estimation with counts from photographic images. It is hoped that sufficient whole schools can be photographed to allow a comparison of the two techniques. Results of the May 1976 study over local waters indicate that photography will be able to detect animals that are at considerable distances below the surface.

If funding and clearances are obtained, the best time for conducting the full survey will be January and February 1977.

5.2 Tagging Studies

Tags have been placed on 3632 porpoise over the past several years and 95 usable returns have been received from fishermen. The longest time between tagging and recovery has been 776 days with a net distance moved of 172 miles. The greatest distance between the points of tagging and recovery is 582 miles over a period of 137 days. While this traditional type of tagging can yield valuable information on stock mixing, movement patterns and abundance, the route taken by an animal between tagging and recovery points can only be inferred. To approach this problem, a multi-agency cooperative program has been established to develop a satellite-link, radio-tracking device for tracking porpoise for periods up to a year. This work was initiated in June 1976. The lead group is the Fisheries Engineering Laboratory of the Southeast Fisheries Center. Co-investigators include the SWFC, Naval Undersea Center, the Marine Mammal Commission, the Porpoise Rescue Foundation, NASA, and the National Data Buoy Office.

The basic approach involves the miniaturization of an electronics package presently being used to track about 200 drifting objects (e.g., buoys, icebergs), so that affixing the package to the dorsal fin of porpoise will be practical. The development phase is expected to take a little over a year.

Congress approved the President's request for a large-scale tagging program and plans are underway to begin a major tagging effort during the 1977 Fiscal Year.

5.3 Vessel-Based Distribution Surveys

During January and February of 1976 the NOAA vessels *David Starr Jordan* and *Townsend Cromwell* explored known distribution ranges, including boundary regions, of porpoise stocks involved in the yellowfin tuna fishery. A total of 20,640 miles was traversed in 118 vessel days with 935 actual search hours. The cruise tracks of the *Jordan* and *Cromwell* are shown in Figure 11.

During these cruises some 309 observations were made of marine mammals, 191 of these being of porpoise schools. In general, the results indicate that the ranges of the porpoise stocks are more extensive than had previously been documented by NMFS. Some of the porpoise sighted appear to be of races different from those known to be involved in the fishery. This correlates with fishermen's statements that the spinner and spotted dolphins in the western and southern areas of the fishery are dissimilar to those in the north and east. No whole specimens have ever been obtained from those western and southern areas. A second distribution survey is scheduled to take place in January and February 1977.

6.0 SUMMARY

An overview of the Research Program including background and findings was presented. Specific supporting analyses and reports are presently available or will shortly be available from the SWFC. The status of the porpoise populations is being reported separately. Among the research results are the following (reported by section of the report):

Fleet Performance in Mortality Reduction (Section 2)

- (1) There will be 55 NMFS observer trips in 1976. Of these at least 15 are expected to obtain data outside the CYRA.
- (2) The species composition of the kill has not changed but the whitebelly spinner stock is involved in a higher proportion of the kill of spinner dolphins than last year while the eastern spinner stock involvement has sharply dropped. These changes reflect a shift in this year's early-season fishing to areas outside the range of the eastern spinner.
- (3) In comparing the physical causes of mortality it was shown that there was little change in entanglement but sizable drops in kill per set resulting from entrapment and sacking-up-- particularly for spinner porpoise.

- (4) The U.S. fleet had reduced its 1976 kill of porpoise by 67 percent in the first 3-1/2 months of the year when compared to the same time period of 1975. The current projection for the 1976 U.S. kill is about 71,000 animals.
- (5) The U.S. fleet has continued to improve its performance in releasing porpoise alive. Under standardized conditions of numbers of tuna and porpoise and species of porpoise caught, the kill per porpoise set fell 21 percent in 1976 from 1975. The overall decline in kill per set from 1973 to 1976 is 55 percent under standardized conditions. A statistical analysis confirmed the need to use standardized conditions in comparing indices of performance from year to year.
- (6) Increases in the number of rescuers decrease the kill due to sacking up. More rescuers were used and they were more effective in 1976 than in 1975, resulting in the drop in kill per set due to sacking up.
- (7) The substantial increase in the use of speedboats to prevent net collapse is probably the single most-important factor in reducing the kill per set in 1976. Statistically it can account for about 60 percent of the drop in kill per set. The balance is probably due to more efficient backdowns, increased use of rescuers and more efficient rescuers.

- (8) Analysis of the rate of entanglement in nets with the present safety panels indicates that the mesh size is too large (about 2" mesh) and the area covered is too small. In comparison, the experimental gear vessels with 1-1/4" mesh and more extensive areal coverage have much lower rates of entanglement.

Mortality Reduction Technology (Section 3)

- (9) During the gear charters, speedboats were successfully used to hold the net open and prevent collapse, under various wind and current conditions. Their use was successful from all aspects of concern on these charters as had been the case during previous gear research cruises.
- (10) Analyses for several types of porpoise aprons were presented and they showed that more favorable results were gained as the amount of small-mesh webbing in the backdown area was increased.
- (11) Preliminary results of the NMFS/industry gear test show encouraging results but data are unexpectedly sparse and definitive conclusions cannot be drawn at this time. Vessels with either test system appear to have improved performance in porpoise release when compared to vessels with standard porpoise rescue equipment, although this improvement may not be due to the test systems alone. Both test systems have problems that must be resolved and these problems are believed to be solvable.

- (12) Work to reduce the approximately 5 percent of the kill that is due to rollup continued with commercial use of anti-torque cable and a contract for evaluation of concepts for an anti-rollup purse block.
- (13) Testing of the large-volume purse seine concept has been suspended because extensive repairs and modifications are required to return the NMFS net to prime fishing condition. Also, the *Bold Contender* system is showing more encouraging results. Testing during FY 1976 was inconclusive.
- (14) Testing of the zipper system to separate porpoise and tuna prior to backdown has been terminated due to technical problems and the extensive mixing and movements of the porpoise and tuna in the net. The concept appears impractical from technical and behavioral standpoints.
- (15) Testing of fluorescent ribbons as current indicators has been abandoned due to excessive time for deployment and erroneous indications of current direction.

Porpoise Biological Studies (Section 4)

- (16) Gross annual reproductive rates of offshore spotted and eastern spinner dolphins have been re-computed with more-recent data.

The estimates are 13 percent and 10 percent, respectively. The preliminary estimate for the whitebelly spinner is 11 percent.

- (17) Basic life history information has been completed for the offshore spotted and eastern spinner dolphins. The spotted work has been published and the eastern spinner manuscript has been submitted for publication. The whitebelly spinner, striped, and common dolphins are receiving increased attention. In addition, analyses of changes in behavior will be conducted from data on hand and a behavioral charter cruise will be fielded in October 1976.

Porpoise Stock Assessment (Section 5)

- (18) Tests of various photographic films were conducted over local schools of porpoise. The results are to be used in aerial survey preparatory work over the tuna fishing grounds this summer or fall (1976).
- (19) Returned porpoise tags now number 95 with a maximum known movement of 582 miles in 137 days. The maximum time between tagging and recovery recorded to date is 776 days. A co-operative satellite-link radio tag program has been initiated.

- (20) A two-vessel survey in January-February 1976 extended the NMFS documented range of dolphins involved in the tuna fishery. Some of the stocks in these boundary areas appear different from those previously documented by NMFS as involved in the fishery. No whole specimens from these stocks are yet available.
- (21) Estimates of porpoise stock abundance and changes over time are being reported separately (SWFC, 1976).

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Members of the Program on the roll on August 21, 1976 were John T. Everett (Program Leader), assisted by LT. Terry D. Jackson (NOAA Corps) and:

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8.0 LITERATURE CITED

- Bold Contender* Cruise Report, 1976. Report of the chartered seiner
M/V *Bold Contender*, September 22, 1975 to December 4, 1975. 12p.
- Coe, J.M. 1976. The effectiveness of the porpoise apron in improving
the backdown procedure. SWFC Admin. Rept. No. LJ-76- (In preparation)
- Department of Commerce. 1974. Report to the Congress on the research
and development program to reduce the incidental take of marine
mammals, October 21, 1972 through October 20, 1974. 57p.
- _____. 1975. Report of the Secretary of Commerce
on Administration of the Marine Mammal Protection Act of 1972,
May 1, 1974 to March 31, 1975.
- _____. 1976. Report of the Secretary of Commerce
on the Administration of the Marine Mammal Protection Act of 1972.
April 1, 1975 through March 31, 1976. Washington, D.C. 203p.
- Eastern Pacific* Report, 1976. Report of the chartered seiner
M/V *Eastern Pacific*, September 29, 1975 to December 6, 1975. 8p.

Everett, J.T., and N. Lo. 1976. The incidental kill of porpoise during the first half of 1976, the date of reaching the quota and the methodologies utilized in each estimation. SWFC Admin. Rept. LJ-76 - (In preparation)

Everett, J.T., J. Powers, R. McNeely, J. Coe and R. Butler. 1976. The use of speedboats in reducing incidental porpoise mortality in tuna purse seining. SWFC Admin. Rept. LJ-76- (In preparation)

Federal Register. 1975. 40(235): 56899-56907.

Federal Register. 1976a. 41(66): 14401-14403.

Federal Register. 1976b. 41(145): 31227

Fox, W.W., Jr., J.E. Powers and W.H. Lenarz. 1976. Incidental porpoise mortality by U.S. purse seine vessels, January 1 through April 14, 1976. SWFC Admin. Rept. No. LJ-76-7. May 1976.

Fisheries Engineering Laboratory. 1976. Proposal to develop a prototype satellite-linked porpoise tracking system. Bay Saint Louis, Miss., July 1976. 38p.

IATTC. 1976. Annual Report of the Inter-American Tropical Tuna Commission. 1975. 176p.

Kimura, M. and W.F. Perrin. 1976. Progress report on studies of the biology of the striped dolphin, *Stenella coeruleoalba* in the eastern tropical Pacific. SWFC Admin. Rept. No. LJ-76-11. 51p.

NOAA Tuna-Porpoise Committee. 1972. Report of the NOAA Tuna-Porpoise Review Committee, September 8, 1972. 63p.

Perrin, W.F., D.B. Holts, and R.B. Miller. 1976a. Growth and reproduction of the eastern spinner dolphin. A geographical form of *Stenella longirostris* in the eastern tropical Pacific. SWFC Admin. Rept. No. LJ-76-13. 84p.

. 1976b. Preliminary estimates of growth and reproduction of the whitebelly spinner dolphin, a geographical form of *Stenella longirostris* in the eastern tropical Pacific. SWFC Admin. Rept. No. LJ-76-12. 37p.

Perrin, W.F., J.M. Coe, and J.R. Zweifel. 1976. Growth and reproduction of the spotted porpoise, *Stenella attenuata*, in the offshore eastern tropical Pacific. Fish. Bull. Vol. 74: 229-269.

Perrin, W.F., R.B. Miller, P.A. Sloan. 1976. Reproductive parameters of the offshore spotted dolphin, a geographical form of *Stenella attenuata*, in the eastern tropical Pacific, 1973-1975. SWFC Admin. Rept. LJ-76- (In preparation)

Powers, J.E. 1976. Estimated incidental porpoise mortality in the eastern Pacific tuna fishery for 1975. SWFC Admin. Rept. LJ-76-4. 14p.

SWFC. 1975. Progress of research on porpoise mortality incidental to tuna purse-seining fishing for fiscal year 1975. SWFC Admin. Rept. LJ-75-68. 98p.

SWFC. 1976. Report of the workshop on stock assessment of porpoises involved in the eastern Pacific yellowfin tuna fishery. SWFC Admin. Rept. LJ-76- (In preparation)

U.S. Court of Appeals for the District of Columbia Circuit. 1976. Case Nos. 76-1479, 76-1480, 76-1481, 76-1482, 76-1483. Decided August 6, 1976.

U.S. District Court for the District of Columbia. 1976. Committee for Humane Legislation, Inc. v. Richardson, Civil Action No. 74-1465. May 11, 1976.

9.0 TABLES

Table 1. Estimated eastern tropical Pacific tuna catch (1000's short tons)^{1/}, of U.S. and non-U.S. countries by species and gear type, 1971-1975

	Year				
	1971	1972	1973	1974	1975
<u>2/ 3/</u>					
Yellowfin tuna associated with porpoise	79	132	127	99	111
Total yellowfin tuna by purse seine	107	160	178	165	153
Total yellowfin tuna by all gear	110	163	184	170	157
Total tuna, all species	195	187	207	224	229
U.S. ^{3/}					
Yellowfin tuna associated with porpoise	2	15	18	14	19
Total yellowfin tuna by purse seine	19	27	42	54	61
Total yellowfin tuna by all gear	27	34	46	61	66
Total tuna, all species	57	47	72	94	127
1, all countries ^{3/}					
Yellowfin tuna associated with porpoise	81	147	145	113	130
Total yellowfin tuna by purse seine	126	187	220	219	214
Total yellowfin tuna by all gear	137	197	230	231	223
Total tuna, all species	252	234	279	318	356

Estimated from Inter-American Tropical Tuna Commission (IATTC) statistics.

All U.S. domestic tuna landings (all areas and all species) for the years 1971-75 are 237, 267, 260, 276 and 284 thousand short tons, respectively. (Source: U.S. Dept. Comm., 1976 *Fisheries Statistics of the United States*, 1975. CFS No. 6900, 100 p.)

Assuming all yellowfin tuna caught west of the IATTC Yellowfin Regulatory Area is by purse seine and by U.S. flag vessels.

Table 2. Species composition of the observed killed and seriously injured^{1/} porpoise during the first half of 1976

Species	Killed	Seriously Injured ^{1/}
Spotted Dolphin (<i>Stenella attenuata</i>)	3,142	93
Spinner dolphin (<i>S. longirostris</i>)		
Eastern	164	9
Whitebelly	1,415	39
Unidentified	101	19
All spinners	1,680	67
Common dolphin (<i>Delphinus delphis</i>)	174	17
Others	136	4
Total Porpoise	5,132	180

^{1/} Bleeding, with broken bones, or caught in power equipment. Column does not add to total because of rounding.

Table 3 . Estimated physical causes of mortality incidental to purse seine fishing for yellowfin tuna in 1975 and 1976^{1/}.
Numbers are in percent of total mortality of species.

Cause	Spotted dolphin	Spinner dolphin	Others
1975			
Individual entanglement	34.3	40.0	27.8
Mass entrapment in net folds and canopies	45.2	40.2	64.0
"Sacked up" ^{2/}	15.2	15.4	3.3
Other	2.0	1.9	3.2
Unknown	3.3	2.5	1.7
Total ^{3/}	100.0	100.0	100.0
1976			
Individual entanglement	39.7	54.5	38.8
Mass entrapment in net folds and canopies	42.1	36.2	46.5
"Sacked up"	7.0	1.6	7.5
Other	0.5	2.8	0.4
Unknown	10.7	4.9	6.8
Total ^{3/}	100.0	100.0	100.0

^{1/}1975 is full year. 1976 is first 30 observer trips.

^{2/}Sacking up operations begin after backdown. The net is further rolled aboard making the volume of confinement for tuna and any remaining porpoise smaller to allow brailing of tuna into the vessel and manual removal of porpoise that could not be backed out.

^{3/}Columns may not add because of rounding.

Table 4. Estimated causes of mortality incidental to purse seine fishing for yellowfin tuna in 1975 and 1976^{1/}.

Entries are in kills per set for porpoise sets in which one or more of the given species was killed.

Cause	Spotted dolphin	Spinner dolphin	Others
1975			
Individual entanglement	5.4	7.3	3.9
Mass entrapment in net folds and canopies	7.1	7.4	9.0
"Sacked up" ^{2/}	2.4	2.8	0.5
Other	0.3	0.3	0.5
Unknown	0.5	0.5	0.2
Total ^{3/}	15.6	18.3	14.0
1976			
Individual entanglement	6.1	7.0	3.9
Mass entrapment in net folds and canopies	6.5	4.6	4.6
"Sacked up"	1.1	0.2	0.7
Other	0.1	0.4	0.0
Unknown	1.6	0.6	0.7
Total ^{3/}	15.4	12.8	10.0

^{1/}1975 is full year. 1976 is first 30 observer trips.

^{2/}Sacking up operations begin after backdown. The net is further rolled aboard making the volume of confinement for tuna and any remaining porpoise smaller to allow brailing of tuna into the vessel and manual removal of porpoise that could not be backed out.

^{3/}Columns may not add due to rounding.

Table 5. Summary statistics of porpoise sets from NMFS observer trips, 1971-1976.^{1/}
Numbers in parentheses are sample sizes.

Statistic	1971	1972	1973	1974	1975	1976
(1) Total number of porpoise sets	51	273	705	993	948	425
(2) Number of pure spotted dolphin sets	23	117	302	425	361	149
(3) Number of pure spinner dolphin sets	0	0	17	15	11	3
(4) Number of mixed spotted and spinner sets	25	132	279	365	412	206
(5) Number of common dolphin sets	2	23	105	142	96	35
(6) Number of others and unknown porpoise sets	1	1	2	46	68	32
(7) Average tons of yellowfin per set	18(48)	20(272)	14(705)	11(993)	13(948)	13(425)
(8) Average number of porpoise caught per set	219(48)	486(245)	378(705)	355(980)	634(947)	939(392)
(9) Average porpoise school size per set ^{2/}	298(48)	1007(239)	907(703)	1163(866)	1216(945)	1542(405)
(10) Average porpoise kill per set	70(48)	43(272)	19(705)	12(993)	16(947)	12(425)
(11) Average porpoise kill per ton of yellowfin	3.8	2.2	1.3	1.1	1.3	0.9
(12) Percent porpoise kill per porpoise caught	31.9	8.9	4.9	3.4	2.5	1.3
(13) Percent of school captured ^{2/}	73.5	48.3	41.7	30.5	52.2	60.4
(14) Percent of school killed ^{2/}	23.5	4.3	2.1	1.0	1.3	0.8
(15) Percent of sets catching yellowfin	92(48)	89(273)	82(705)	74(993)	82(948)	82(425)
(16) Percent of sets catching porpoise	100(48)	91(273)	86(705)	83(993)	91(947)	90(392)
(17) Percent of sets catching porpoise with zero killed	2(48)	12(248)	18(601)	22(827)	24(863)	31(352)

^{1/} Five trips in 1971, 12 in 1972, 22 in 1973, 36 in 1974, 31 in 1975, and the first 30 observer trips in 1976.

^{2/} Estimates generally have a low precision.

Table 6. Frequency distribution of porpoise kill per set for all porpoise sets, 1971-1976

Kill/ set interval	1971			1972			1973			1974		
	Sets		Kill	Sets		Kill	Sets		Kill	Sets		Kill
	Number	%		Number	%		Number	%		Number	%	
0	1	2.1	0	54	19.9	0	225	32.3	0	346	34.8	0
1-24	20	41.7	199	132	48.5	1064	362	51.9	2588	518	52.2	3416
25-50	13	27.1	474	35	12.9	2131	48	6.9	1696	80	8.1	2843
51-100	6	12.5	447	20	7.4	491	33	4.7	2340	27	2.7	1931
>100	8	16.7	2237	31	11.4	8047	29	4.2	6353	22	2.2	3860
Total ^{2/}	48	100.0	3357	272	100.0	11,733	697	100.0	12,977	993	100.0	12,050

Kill/ set interval	1975			1976 ^{1/}		
	Sets		Kill	Sets		Kill
	Number	%		Number	%	
0	285	30.1	0	169	39.5	0
1-24	505	53.3	3338	197	46.4	1369
25-50	81	8.6	2809	32	7.5	1080
51-100	43	4.5	3028	15	3.5	911
>100	33	3.5	5973	12	2.8	1771
Total ^{12/}	947	100.0	15147	425	100.0	5132

^{1/}First 30 observer trips of 1976.

^{2/}Columns may not add due to rounding.

Table 7. Statistics from sets made on pure schools
of spotted dolphins by class III vessels
(1973-1976) ^{1/}

Number of porpoise captured	Catch of yellowfin				All sets	
	0-20 tons		Greater than 20 tons			
	Number of sets	Kill per set	Number of sets	Kill per set	Number of sets	Kill per set

1973

0-500	118	4.64	19	14.89	137	6.07
Greater than 500	11	7.82	14	27.43	25	18.80
All sets	129	4.91	33	20.21	162	8.03

1974

0-500	248	3.69	24	10.29	272	4.27
Greater than 500	23	3.00	19	37.11	42	18.43
All sets	271	3.63	43	22.14	314	6.17

1975

0-500	155	2.86	11	14.82	166	3.66
Greater than 500	42	4.93	21	11.00	63	6.95
All sets	197	3.30	32	12.31	229	4.56

1976

0-500	73	1.96	5	2.80	78	2.01
Greater than 500	46	4.63	13	16.85	59	7.32
All sets	119	2.99	18	12.94	137	4.30

^{1/} First half of year

Table 8. Statistics from sets made on mixed schools
of spotted and spinner dolphins
by class III vessels ^{1/}
(1973-1976)

Number of porpoise captured	Catch of yellowfin				All sets	
	0-20 tons		Greater than 20 tons			
	Number of sets	Kill per set	Number of sets	Kill per set	Number of sets	Kill per set
1973						
0-500	98	15.56	15	39.07	113	18.68
Greater than 500	31	33.68	38	100.42	69	70.43
All sets	129	19.91	53	83.06	182	38.30
1974						
0-500	164	8.83	12	53.58	176	11.88
Greater than 500	59	22.76	30	70.47	89	38.84
All sets	223	12.52	42	65.64	265	20.94
1975						
0-500	120	8.78	10	22.10	130	9.80
Greater than 500	128	18.41	79	56.29	207	32.86
All sets	248	13.75	89	52.45	337	23.97
1976						
0-500	58	4.60	3	8.67	61	4.80
Greater than 500	97	15.28	44	47.74	141	25.41
All sets	155	11.28	47	45.25	202	19.19

^{1/}First half of year

Table 9. Statistics for sets made on pure schools of spotted dolphins and mixed sets of spotted and spinner dolphins, 1973-1976 ^{1/}

Year	Pure spotted dolphin			Mixed spotted and spinner dolphin			All sets			
	Sets	Kill	Yellowfin catch (tons)	Sets	Kill	Yellowfin catch (tons)	Sets	Kill	Yellowfin catch (tons)	Kill/Set
1973	162	1301	2206	182	6971	3444	344	8272	5650	24.05
1974	314	1936	3537	265	5548	3280	579	7484	6817	12.93
1975	229	1045	2661	337	8077	5400	566	9122	8061	16.12
1976	137	589	1397	202	3876	3420	339	4465	4817	13.17

^{1/}First half of the year, Class III vessels only.

Table 10. Data on rescuer effectiveness in 1975 and 1976. Only those sets in which live porpoise are left in the net after backdown are included.

Number of rescuers	1975			1976 ^{1/}		
	Number of sets	Number of live porpoise in net after backdown	Number rescued after backdown and prior to end of sack-up	Number of sets	Number of live porpoise in net after backdown	Number rescued after backdown and prior to end of sack-up
0	16	310	0	1	10	0
1	205	3257	1167	26	261	142
2	358	7026	4648	177	2407	1684
3	48	1550	1233	43	746	600
4	33	1658	1138	21	1101	677
5	9	207	166	5	110	81
6	4	152	71	5	382	192
7	2	98	45	1	225	100
8	2	170	100	0	0	0
9	0	0	0	2	150	140
Total	677	14428	8568	281	5392	3616

^{1/} First 30 observer trips.

Table 11. Count of notations and scores of entanglement by areas of the net for the first half of 1976 ^{1/}

Cruise ^{3/}	Area of Net ^{2/}							
	1		2		3		4	
	Count	Score	Count	Score	Count	Score	Count	Score
A	9	7	2	1	9	3	1	1
B	2	1	0	0	0	0	0	0
C	21	7	0	0	0	0	0	0
D	0	0	3	2	3	3	0	0
E	11	3	3	1	11	2	0	0
F	9	2	46	7	31	9	1	1
G	12	3	18	6	26	8	1	1
H	1	1	1	1	0	0	1	1
I	10	2	0	0	6	2	2	1
J	22	9	0	0	16	6	1	1
K	33	7	7	2	3	1	0	0
L	0	0	16	6	0	0	0	0
M	4	2	3	1	3	1	1	1
N	34	23	0	0	0	0	3	3
O	34	10	1	1	0	0	7	4
P	3	1	0	0	0	0	0	0
Q	29	18	9	3	13	6	7	5
R	6	3	1	1	0	0	0	0
S	48	12	10	2	13	5	1	1
T	1	1	2	1	0	0	0	0
U	2	2	0	0	0	0	0	0
V	4	4	2	2	1	1	1	1
Total	295	118	124	37	135	47	27	21

^{1/} Of the first 30 observed trips of 1976, 22 had net diagrams with usable notations of entanglement. A score represents the fact that the given area of the net had one or more notations of entanglement in that area.

^{2/} Area 1 is the safety panel; Area 2 is the outboard of the panel; Area 3 is directly under the panel; and Area 4 is inboard of the panel.

^{3/} Observer-recorded mesh sizes were: A, B, C - 1.5"; D, E - 1.7"; F - 1.8"; and G - V - 2.0".

Table 12. Kill per set for porpoise individually entangled,
for normal sets testing variations of the
porpoise apron device

Apron Type (No. Cruises)	Spotters (No. sets)	Spinners (No. sets)	Others (No. sets)
Prototype 2" Apron on 2" panel (1)	No data	No data	No data
Standard 2" Apron on 2" panel (5)	4.20 (40)	5.08 (22)	2.23 (3)
1-1/4" Apron on 2" panel (2)	3.56 (27)	3.47 (9)	22.50 (1)
1-1/4" Apron on 1-1/4" panel (2)	1.13 (23)	1.80 (10)	1.00 (1)
1975 Non-Apron Class III (23)	4.77 (340)	6.11 (184)	3.31 (35)
1976 Non-Apron Class III (15)	6.57 (142)	7.69 (85)	2.26 (13)

Table 13. Kill per set by entrapment in folds or canopies for normal sets testing variations of the porpoise apron device

Apron Type (No. Cruises)	Spotters (No. sets)	Spinners (No. sets)	Others (No. sets)
Prototype 2" Apron on 2" panel (1)	No data	No data	No data
Standard Apron on 2" panel (1)	8.18 (40)	3.31 (23)	1.00 (1)
1-1/4" Apron on 2" panel (2)	0.65 (27)	1.16 (9)	11.25 (1)
1-1/4" Apron on 1-1/4" panel (2)	0.22 (23)	1.80 (10)	0.00 (1)
1975 Non-Apron Class III (23)	3.93 (340)	5.61 (184)	9.08 (35)
1976 Non-Apron Class III (15)	3.51 (142)	3.82 (85)	5.48 (13)

Table 14. Average number of porpoise "left-in" alive after backdown by vessels testing variations of the porpoise apron, normal sets. Sample sizes in parentheses.

Species Composition	Pure Spotted				Mixed Spotted and Spinners				Other Species				Overall Average	Adjusted to 1975
	0-20	> 20	0-20	> 20	0-20	> 20	0-20	> 20	0-20	> 20	0-20	> 20		
Tons Yellowfin														
No. Porpoise	0-500	> 500	0-500	> 500	0-500	> 500	0-500	> 500	0-500	> 500	0-500	> 500		
Prototype Apron														
Standard 2" Apron on 2" panel	1.55 (11)	--	7.91 (11)	13.00 (4)	9.25 (16)	--	14.89 (9)	17.38 (8)	5.25 (4)	--	--	--	9.49 (63)	9.05
1-1/4" Apron on 2" panel	6.00 (9)	35.00 (1)	0.00 (1)	6.33 (3)	10.44 (12)	--	15.75 (4)	31.67 (6)	2.00 (2)	--	13.33 (3)	--	13.30 (41)	11.96
1-1/4" Apron on 1-1/4" panel	3.63 (19)	--	0.00 (1)	5.00 (1)	8.21 (14)	2.00 (1)	11.38 (8)	2.00 (1)	25.00 (1)	--	--	--	6.72 (46)	7.41
'75 Non-Apron Class III	5.21 (131)	10.94 (17)	7.02 (42)	6.72 (18)	10.31 (86)	9.86 (7)	17.88 (108)	43.78 (55)	9.28 (39)	26.50 (2)	30.80 (15)	26.29 (7)	14.49 (557)	14.49
'76 Non-Apron Class III	4.71 (38)	2.00 (2)	7.86 (35)	10.27 (11)	10.17 (24)	15.00 (1)	15.53 (70)	51.65 (31)	20.00 (2)	--	10.00 (5)	44.80 (5)	17.12 (220)	14.94

1/ No data

Table 15. Average kill per set in normal¹ sets by vessels testing the *Bold Contender* system (9), the fine mesh system (5) and by Class III observed vessels in 1976 (21). All except one fine mesh cruise were inside the CYRA in 1976.

Pure spotted porpoise schools				
Catch (tons)	Captured	Type 2/	Sets	Kill per set
0-20	0-500	B.C.	45	0.42
		F.M.	20	0.90
		OBS.	43	1.20
0-20	>500	B.C.	7	0.57
		F.M.	3	0.0
		OBS.	37	2.24
>20	0-500	B.C.	3	0.33
		F.M.	1	0.00
		OBS.	4	3.50
>20	>500	B.C.	13	4.85
		F.M.	No data	No data
		OBS.	11	16.45
Pure mixed spotted and spinner schools				
0-20	0-500	B.C.	23	1.54
		F.M.	15	1.73
		OBS.	37	4.43
0-20	>500	B.C.	27	6.42
		F.M.	12	8.08
		OBS.	77	9.93
>20	0-500	B.C.	2	2.50
		F.M.	2	6.00
		OBS.	1	20.00
>20	>500	B.C.	12	19.64
		F.M.	8	35.36
		OBS.	35	44.34

¹ Normal means that porpoise were captured, there were no collapses and no malfunctions while porpoise were in the net.

² B.C. = *Bold Contender* system
 F.M. = Fine-mesh-only system
 OBS. = 1976 NMFS observer vessels, Class III only.

Table 16. Summary of life history information for five porpoise species¹

Species	Importance to Tuna Fisheries	Taxonomy	Adult Size	Diet	Distribution	Movements	Average School Size (range)	Population Size ³	Age at Sexual Maturity	Gestation Period
<u>Tursiops truncatus</u> (bottlenosed)	Small	Inadequate, may be races rather than distinct species	Up to 4m and 400 kg	Fish, squid, crustaceans	World-wide; temperate & tropical waters	May be localized populations and/or extensive migrations	100 (5 - 1500)	Not Available	5 - 12 years	11 - 12 months
<u>Stenella attenuata</u> (spotted)	Large	Several distinct geographical races exist in the eastern tropical Pacific	1.6 to 2 m	Small mesopelagic and epipelagic fish and squid	Nearly all coastal and offshore tropical waters and in some warm temperate regions	Nothing is known of migrations; very limited data available on individual movements	870 (8 - 6000)	2.3 to 4.9 million	6 - 10 years	11.2 months
<u>Stenella longirostris</u> (spinner)	Large	Several distinct races appear to exist in the eastern tropical Pacific	1.5 to 2.2m	Small mesopelagic fish and epipelagic squids	World-wide; tropical inshore and offshore	Same as for spotted	450 (5 - 6000)	1.1 to 1.2 million	4-6 years	10.6 months
<u>Delphinus delphis</u> (common or white-belly porpoise)	Medium	Inadequate, probably only 1 species, but several morphologically distinct populations	1.6 to 2.6m and up to 75 kg	Anchovy, sprats, pipefish, mackerel, sardine cephalopods	World-wide in warm temperate and tropical waters	There may be migratory, and non-migratory populations	580 (5 - 6000)	Not Available	3 years ⁴	10 - 11 months
<u>Stenella coeruleoalba</u> (striped)	Small	Inadequate; probably only a single species but several distinct forms	2.2 m	Mesopelagic fishes, squids and crustacea	Temperate and tropical waters world-wide	Unknown in eastern Pacific, migratory off coastal Japan	210 (20 - 1000)	Not Available	5 - 8 years	10 to 11 months

¹Source, (Fisheries Engineering Laboratory, 1976).

²1975 NMFS observer data, based on over 2000 sightings (all species).

³Estimates under revision. See report of Stock Assessment Workshop.

⁴USSR estimate.

Table 17. Summary of parameter estimates for the whitebelly spinner form of the spinner dolphin, *S. longirostris*, and comparison with estimates for the eastern form. Estimates for parameters 8-11 based on data for 1973, 1974, and 1975 for the whitebelly spinner. All parameters for the eastern spinner are based on data for 1971-1975. Ranges in parentheses.

Parameter	Whitebelly form	Eastern form
1. Length of gestation (common estimate)	10.6 months	
2. Average length at birth. (common estimate)	77 cm	
3. Average length of sexually-adult males, under		
a. 94 g criterion of tests-epididymis weight	179 cm	176 cm
b. 160 g " " "	180	176
c. 400 g " " "	182	174
4. Average length at attainment of sexual maturity in females	169 cm	165 cm
5. Average length of sexually adult females	175 cm	171 cm
6. Proportion of adult females postreproductive	1%	0.7%
7. Proportion of lactating females pregnant (overlapping cycles)	6.8%	0.7%
8. Sex ratio (M:F):		
a. In adult-size (≥ 160 cm)	0.96 (0.63-1.05)	0.94 (0.90-0.97)
b. Overall	1.03 (0.78-1.10)	0.97 (0.89-1.02)
9. Proportion of females reproductive	54% (stable)	44% (stable)
10. Annual pregnancy rate	41% (32-48%)	36% (24-44%)
11. Gross annual reproductive rate	not completed	46% (45-47%)
	11% (9-12%)	8% (5-10%)
	not completed	10% (9.9-10.3%)

10.0 FIGURES

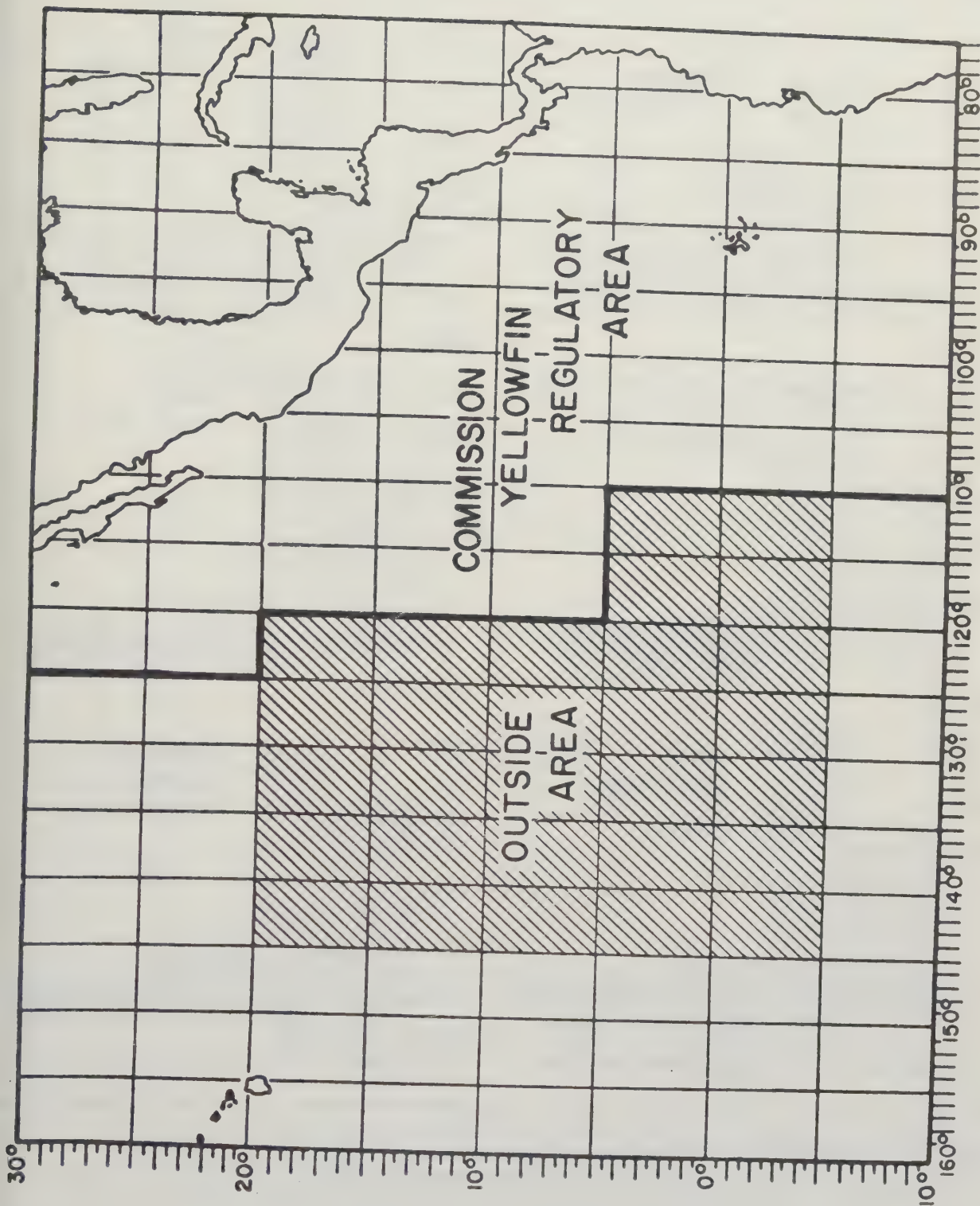


Figure 1. The major part of the Inter-American Tropical Tuna Commission Yellowfin Regulatory Area (CYRA) and the principal zone of fishing outside the CYRA

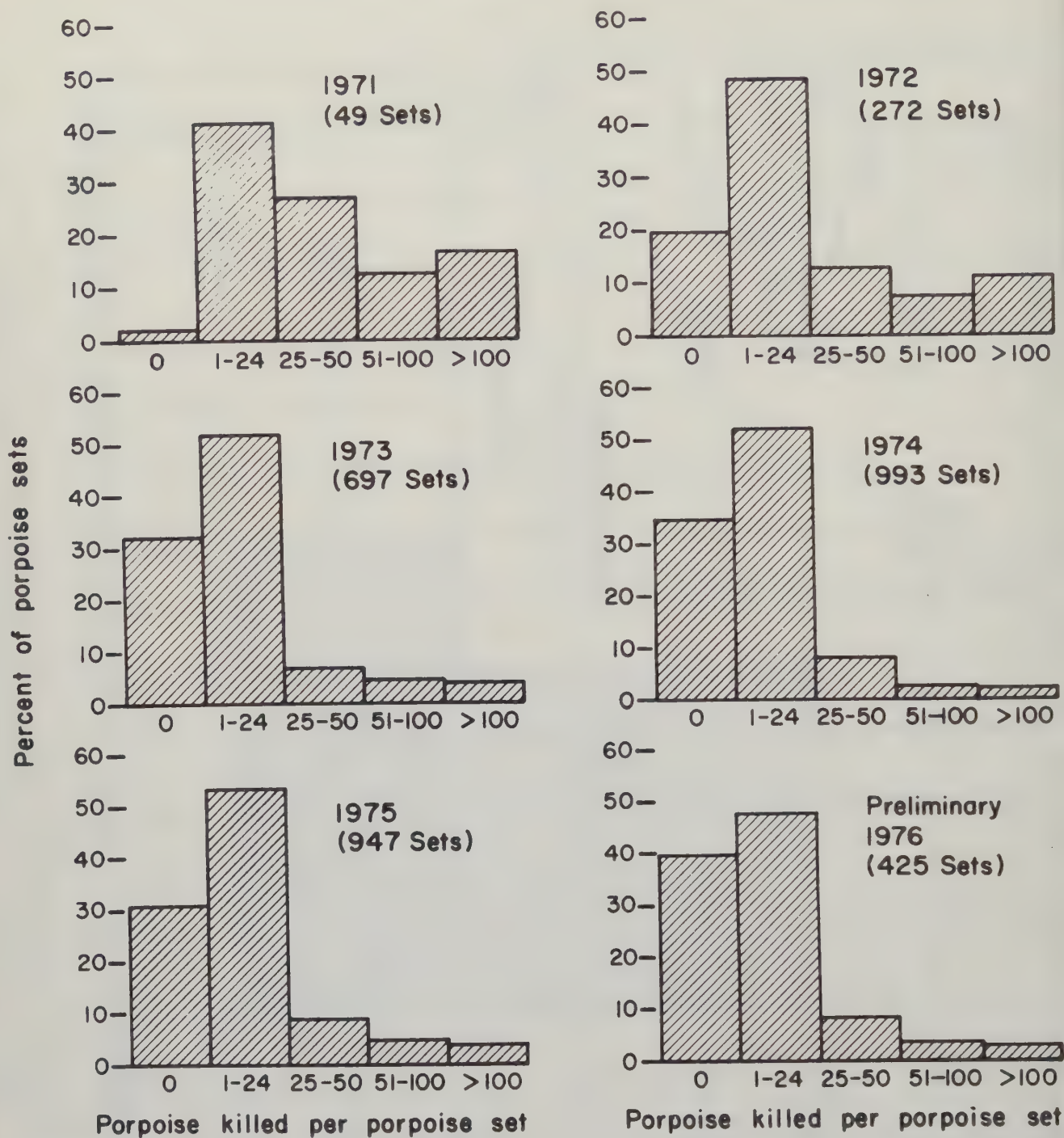


Figure 2. Frequency distributions of porpoise killed per all porpoise sets for 1971-1975, and the first 30 observer trips of 1976

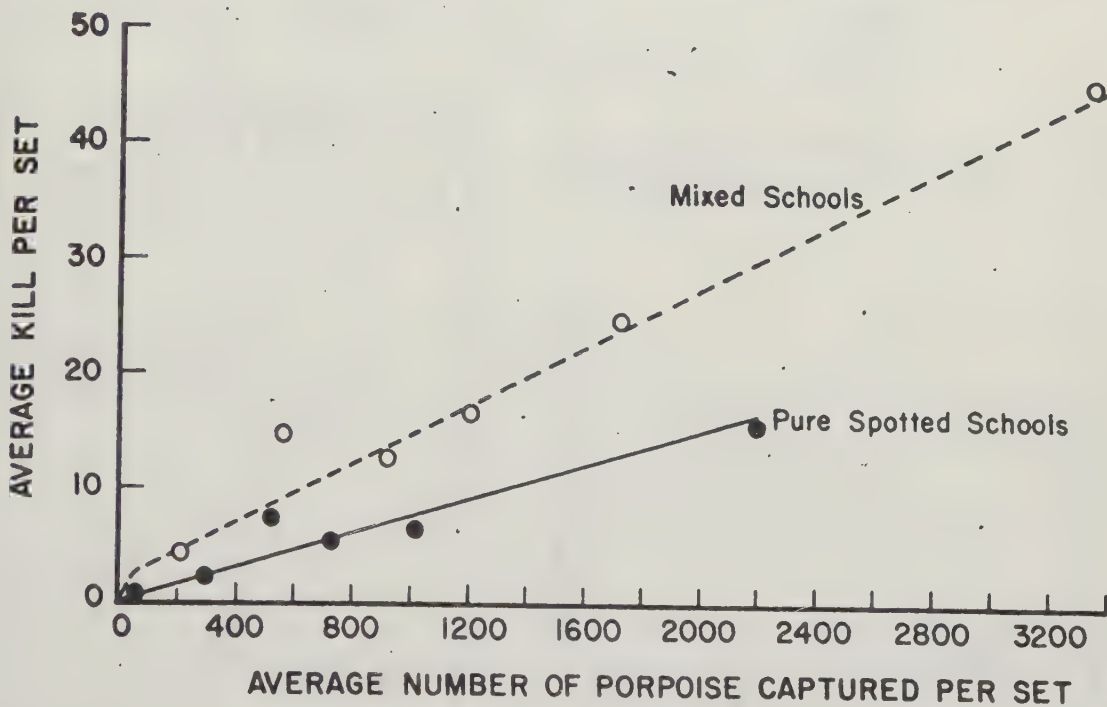
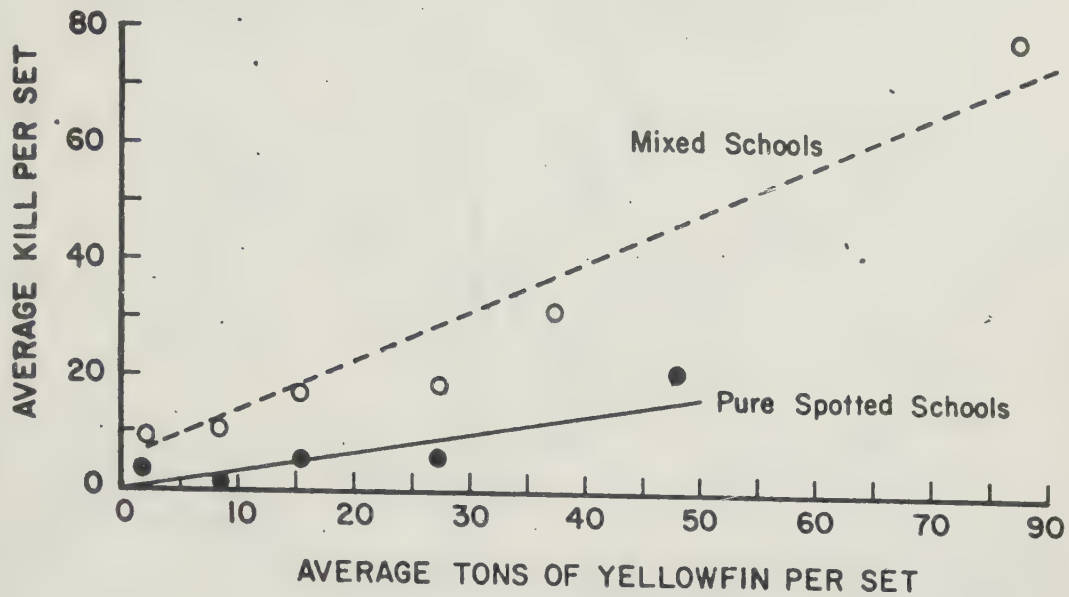


Figure 3. Average kill of porpoise per porpoise set by school type plotted against tons of yellowfin tuna and number of porpoise captured per set for 1976.

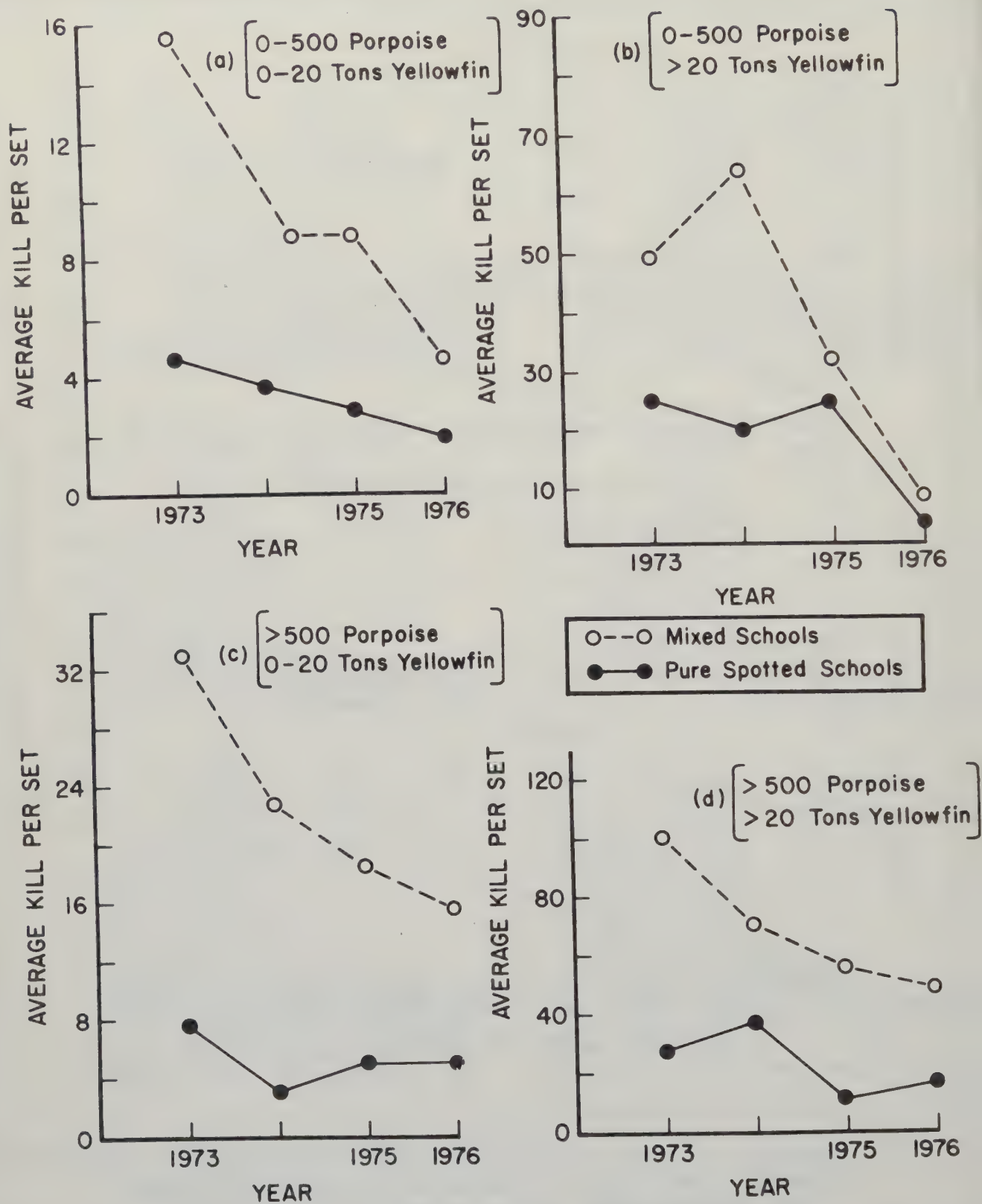


Figure 4. Average kill per set by school type, number of porpoise captured, and catch of yellowfin tuna, 1973-1976

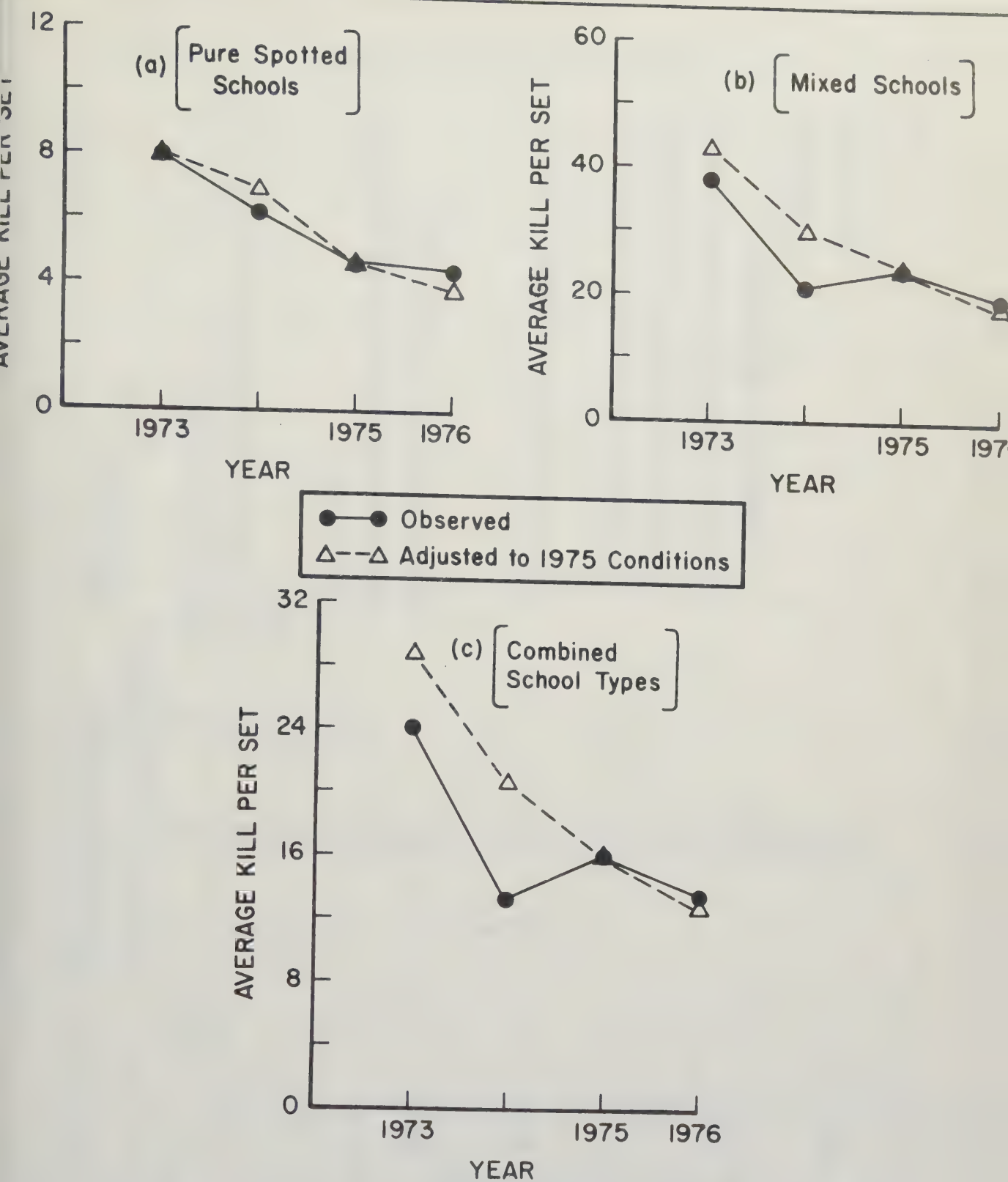


Figure 5. Average kill per set by school type and combined school types, 1973-1976. Closed circles represent observed values and open triangles represent values standardized to 1975 conditions

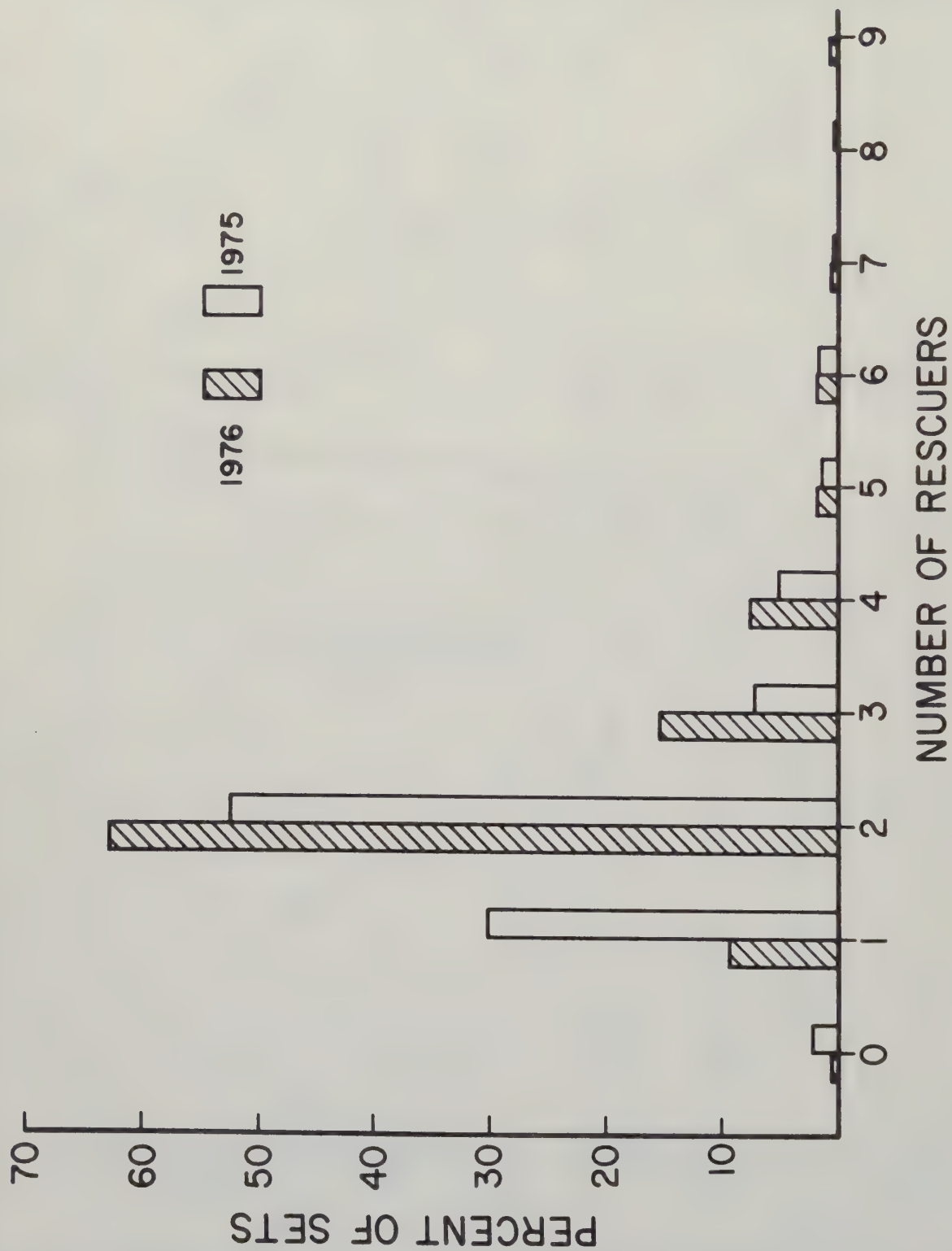


Figure 6. Frequency distribution of rescuers. 1976 data are from first 30 observed trips.

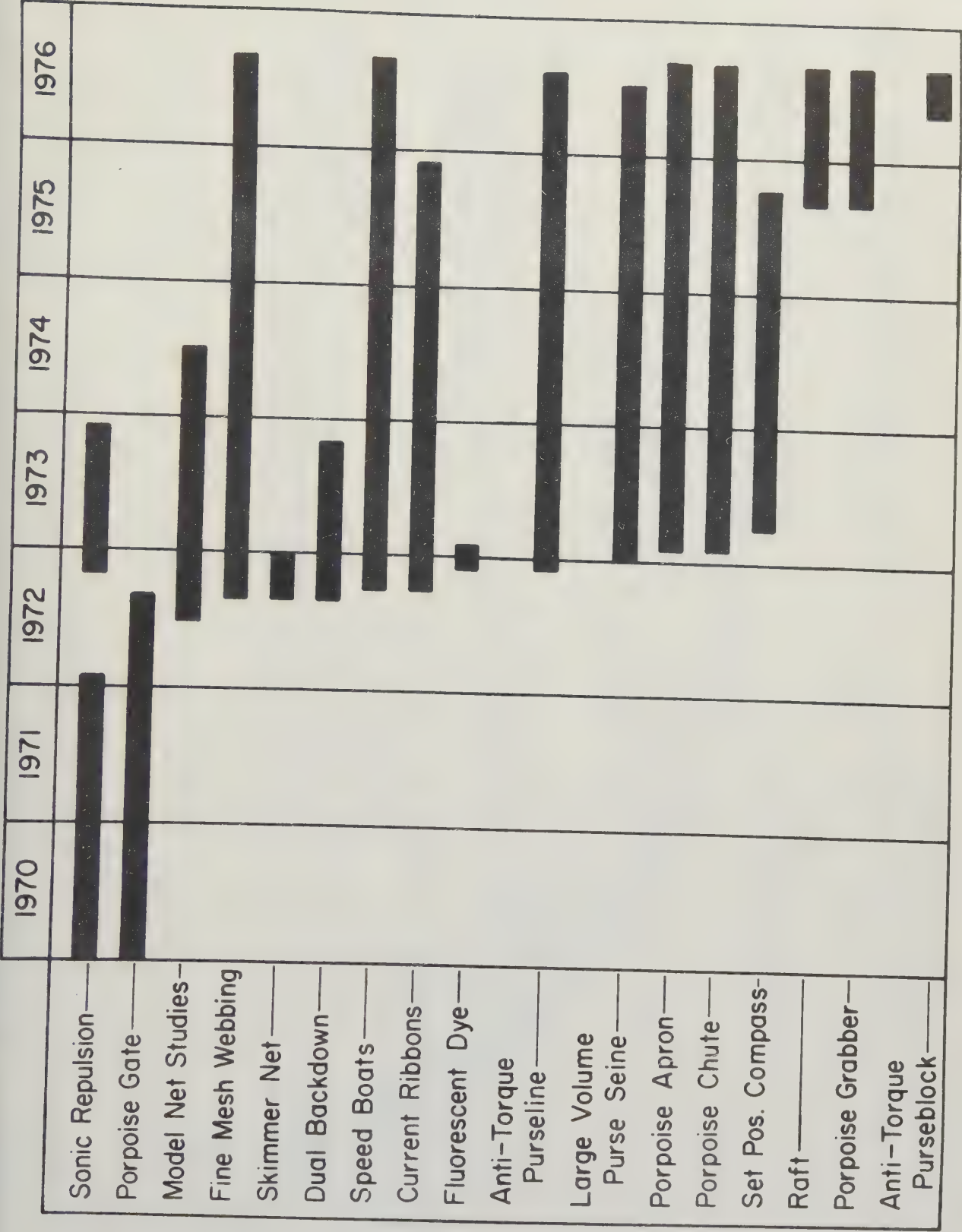


Figure 7. Mortality Reduction studies since 1970 by the Southwest Fisheries Center

BACKDOWN
CENTER LINE

34 FATHOMS

1 MESH, 2 BAR TAPER

PROTOTYPE APRON, 62 FATHOMS, 2" MESH, #36 TWINE
PLACED ON STANDARD 2" MESH SAFETY PANEL, FALL 1974

9 FATHOMS

4 MESH, 2 BAR TAPER

PROTOTYPE 1-1/4" MESH APRON, 81 FATHOMS,
#21 TWINE PLACED ON STANDARD 2" SAFETY
PANEL, WINTER 1975.

9 FATHOMS

4 MESH, 2 BAR TAPER

STANDARD APRON, 71 FATHOMS, 2" MESH, #42
TWINE PLACED ON STANDARD 2" MESH SAFETY
PANEL, SPRING 1975.

16 FATHOMS

5 MESH, 2 BAR TAPER

APRON ON SINGLE DEPTH
SAFETY PANEL,
ALL 1-1/4" MESH
#24 TWINE, FALL
1975.

SINGLE DEPTH
SAFETY PANEL
(180 FATHOMS)

3.5 FATHOMS

1 MESH, 2 BAR TAPER

CHUTE
26 FATHOMS
BUOYS

5 MESH, 2 BAR TAPER

APRON

BOLD CONTENDER
SYSTEM, ALL 1-1/4"
MESH, #24 TWINE
FALL 1975

DOUBLE DEPTH
SAFETY PANEL
(180 FATHOMS)

Figure 3. Experimental net modifications added to the backdown area of purse seine nets designed

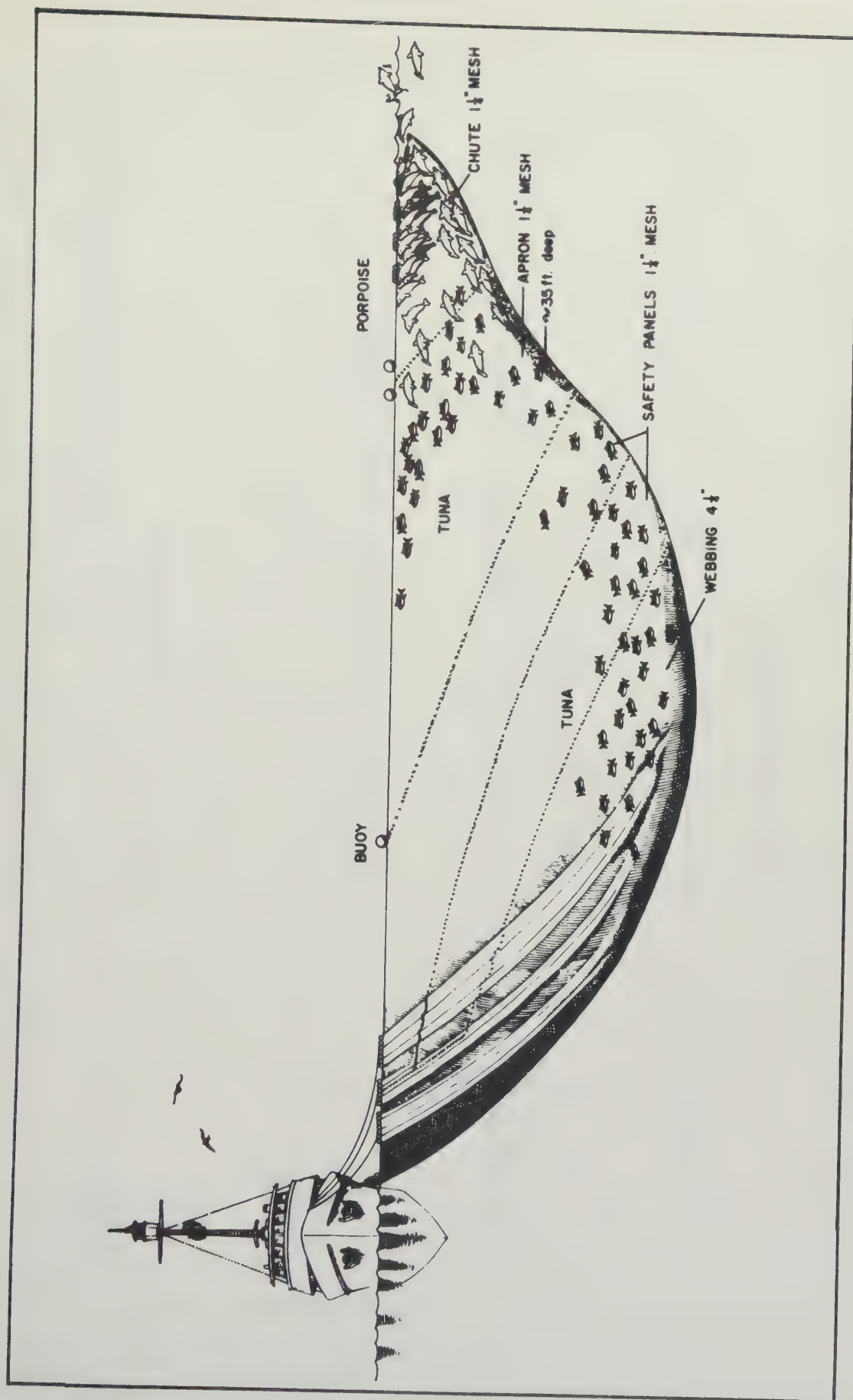


Figure 9. Net cross-section during backdown using apron-chute rescue system

$$\downarrow \text{AVERAGE} = \frac{\Sigma \text{ KILL}}{\Sigma \text{ TONS}}$$

$$\Delta \text{ AVERAGE} = \frac{\Sigma \text{ KILL} / \text{TON} / \text{TRIP}}{\Sigma \text{ TRIPS}}$$

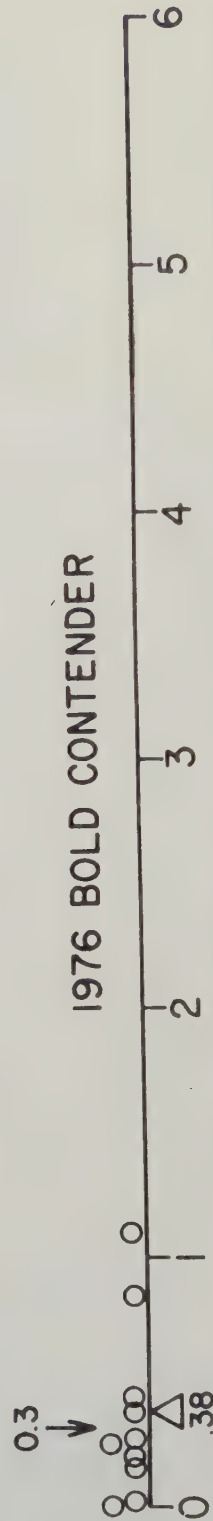
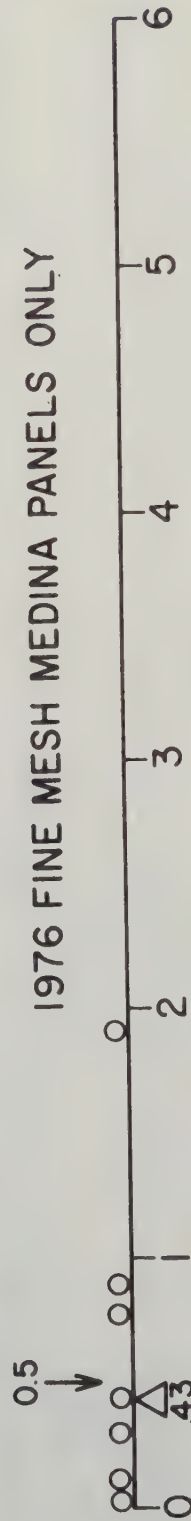
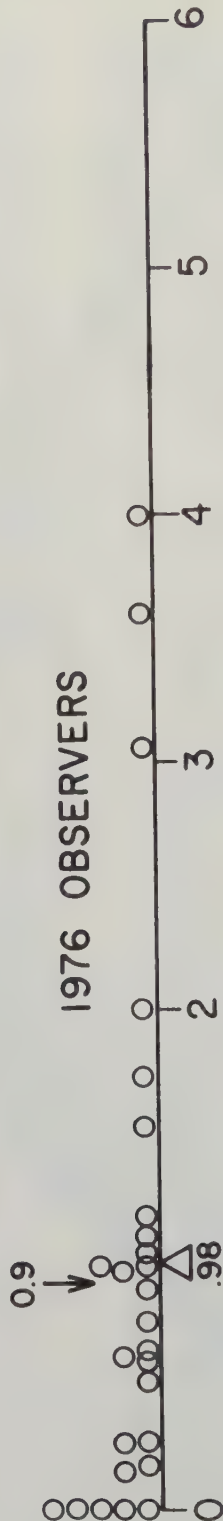
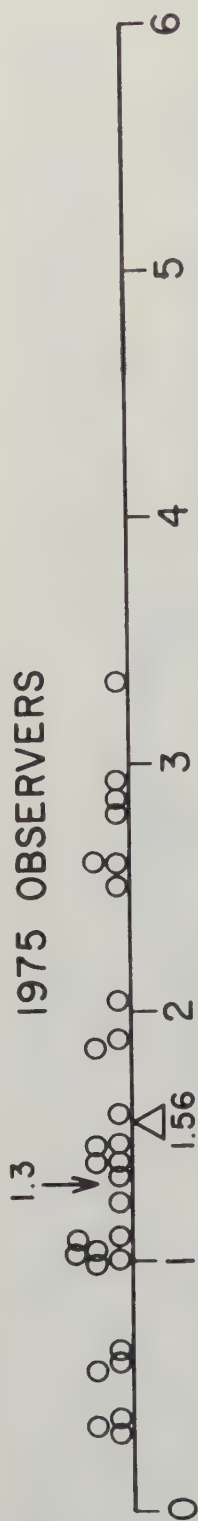


Figure 10. Average kill per ton computed two ways and distribution of kill per ton by trips for all 1975 and first 30 1976 observer trips and information on experimental

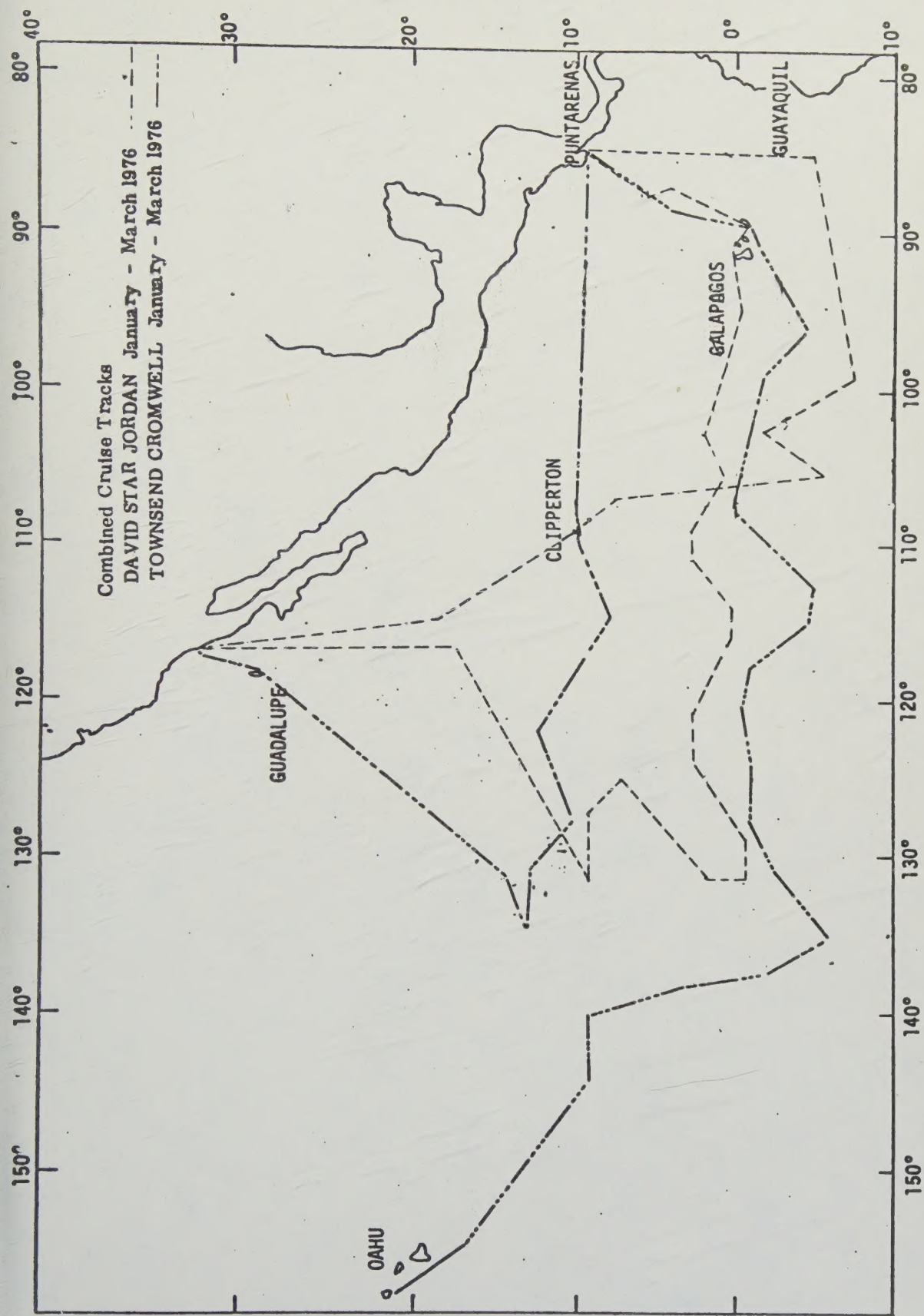


Figure 11. Cruise tracks of 1976 porpoise distribution survey

